THE

OLD RED SANDSTONE;

OR,

NEW WALKS IN AN OLD FIELD.

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NEW WALKS IN AN OLD FIELD.

BY

HUGH MILLER.

THIRD EDITION.

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TO

RODERICK IMPEY MURCHISON, Esq., F.R.S.,

&c &c. &c.,

PRESIDENT OF THE GEOLOGICAL SOCIETY.

In the autumn of last year I sat down to write a few geological sketches for a newspaper; the accumulated facts of twenty years crowded upon me as I wrote, and the few sketches have expanded into a volume. Permit me, honoured Sir, to dedicate this volume to you. Its imperfections are doubtless many, for it has been produced under many disadvantages; but it is not the men best qualified to decide regarding it whose criticisms I fear most; and I am especially desirous to bring it under your notice, as of all geologists the most thoroughly acquainted with those ancient formations which it professes partially to describe. I am, besides, desirous it should be known, and this, I trust, from other motives than those of vanity, that when prosecuting my humble researches in obscurity and solitude, the present President of the Geological So-

ciety did not deem it beneath him to evince an interest in the results to which they led, and to encourage and assist the inquirer with his advice. Accept, honoured Sir, my sincere thanks for your kindness.

Smith, the father of English Geology, loved to remark that he had been born upon the Oolite—the formation whose various deposits he was the first to distinguish and describe, and from which, as from the meridian line of the geographer, the geological scale has been graduated on both sides. I have thought of the circumstance when, on visiting in my native district the birth-place of the author of the *Silurian System*, I found it situated among the more ancient fossiliferous rocks of the north of Scotland—the Lower Formation of the Old Red Sandstone spreading out beneath and around it, and the first-formed deposit of the system, the Great Conglomerate, rising high on the neighbouring hills. It is unquestionably no slight advantage to be placed, at that early stage of life, when the mind collects its facts with greatest avidity, and the curiosity is most active, in localities where there is much to attract observation that has escaped the notice of others. Like the gentleman whom I have now the honour of addressing, I too was born on the Old Red Sandstone, and first broke ground as an inquirer into geological fact in a formation scarce at all known to the geologist, and in which there still remains much for future discoverers to examine and describe. Hence an acquaintance, I am afraid all too slight, with phenomena which, if intrinsically of interest, may be found to have also the interest of novelty to recommend them, and with organisms which, though among

the most ancient of things in their relation to the world's history, will be pronounced new by the geological reader in their relation to human knowledge. Hence, too, my present opportunity of subscribing myself, as the writer of a volume on the Old Red Sandstone,

Honoured Sir,

With sincere gratitude and respect,

Your obedient humble Servant,

HUGH MILLER.

EDINBURGH, May 1, 1841.

NOTE TO THE SECOND EDITION.

THE new matter in the present edition does not much exceed fifteen pages. It chiefly refers, however, to the least-known portion of the system—that middle formation to which the organisms of Balruddery and Carmylie belong, and which has its representative in England and Wales in the immensely developed Cornstones. And hence, perhaps, some little degree of interest in those few additional pages, proportioned to the novelty of the information which they convey. A print has also been added illustrative of this portion of the work. It represents two of the more characteristic organisms of Forfarshire—the reticulated markings of Carmylie, and one of the terminal flaps of its gigantic crustacean.

If I have been thus enabled to add but little, I have found occasion to alter less. One or two slight hints thrown out in the former edition, to direct the attention of the reader to matters merely conjectural, have given place in the present to the facts, now ascertained, at which the conjectures pointed. A few of the other alterations are indicated in the preface, that of the first edition, which, as it marks the progress of the work, I have deemed it proper to retain.

MARCH, 1842.

NOTE TO THE THIRD EDITION.

In the first edition of the Old Red Sandstone, it was stated that, when Cuvier closed his labours in the summer of 1832, there had been ninety-two species of fossil fish named and described, and that the entire geologic scale, from the Palæozoic to the Tertiary formations inclusive, was at that period not known to contain more. It was added, that barren in fossils as the Old Red Sandstone had been hitherto supposed, the day was not distant when its ichthyolites would be found at least equal in number to those of all the geologic formations united at the death of Cuvier. And such has been the progress of geologic discovery, that the prediction, bold as it may have seemed, is already considerably more than fulfilled. Agassiz now enumerates one hundred and five species of fossil fish peculiar to the Old Red Sandstone; and, with the addition of the more doubtful species—some of which, however, were included in the list of Cuvier *—one hundred and fifty. The ichthyolites of one system, and that one deemed poorer in organisms, but a few years since, than

* Such as *Dipterus arenaceus, D. brachypygopterus, D. macropygopterus*, and *D. Valenciennesii.* Agassiz recognises but one species of *Dipterus—D. macrolepidotus.*

any other, are now ascertained to be considerably more numerous than all the ichthyolites of all the systems put together, as estimated by the highest authorities only fourteen years ago.

The reader will find reference made in the present edition to the various divisions into which Agassiz has separated the several families which it describes, and an appended list of all the ichthyolitic species of the system with which the course of discovery has yet brought us acquainted. There have been a good many additions made to the volume, chiefly in the form of notes, and several alterations effected on the text, where statements seemed to require modification. In most cases, however, the original statement has been retained—it has been so, at least, in every instance in which it has been founded upon or disputed by other writers—and the qualification, where qualification was found necessary, has been subjoined as a note. I need here refer to but one of these modifications; and this chiefly that I may have an opportunity of acknowledging my obligations to the meritorious individual through whose kindness I have been furnished with the data on which it has been made. It was stated in the two former editions, that there is a gradual increase of size observable in the progress of ichthyolitic life, from the minute fish of the Silurian System up to the enormous Holoptichius of the Coal Measures—the largest of all the ganoids; and that the Old Red System, whose lower beds border on the deposits of the Silurian fish, and its upper on that of the gigantic ganoid, exhibited in its various formations this gradation of bulk—beginning with an age of dwarfs, and ending

with an age of giants. Since the appearance of the second edition, however, it has been ascertained that there were giants among the dwarfs. The remains of one of the largest fish found anywhere in the system have been discovered in its lowest formation near Thurso, by Mr. Robert Dick, an intelligent tradesman of that place, who, by devoting his leisure hours to the study of Geology, in a singularly rich locality, has been enabled to add not a few interesting facts, to those previously accumulated truths of the science on which its sounder theories can alone be erected; and who has kindly placed at my disposal his collection of fossils. And the positive proof which they furnish has convinced me, that the theory of a gradual progression in size, from the earlier to the later Palæozoic formations, though based originally on no inconsiderable amount of negative evidence, must be permitted to drop.

AUGUST, 1846.

PREFACE TO THE FIRST EDITION.

NEARLY one-third of the present volume appeared a few months ago in the form of a series of sketches in the *Witness* newspaper. A portion of the first chapter was submitted to the public a year or two earlier, in *Chambers's Edinburgh Journal*. The rest, amounting to about two-thirds of the whole, appears for the first time.

Every such work has its defects. The faults of the present volume—faults all too obvious, I am afraid—would have been probably fewer had the writer enjoyed greater leisure. Some of them, however, seem scarce separable from the nature of the subject: there are others for which, from their opposite character, I shall have to apologize in turn to opposite classes

of readers. My facts would, in most instances, have lain closer had I written for geologists exclusively, and there would have been less reference to familiar phenomena. And had I written for only general readers, my descriptions of hitherto undescribed organisms, and the deposits of little-known localities, would have occupied fewer pages, and would have been thrown off with perhaps less regard to minute detail than to pictorial effect. May I crave, while addressing myself, now to the one class and now to the other, the alternate forbearance of each?

Such is the state of progression in geological science, that the geologist who stands still for but a very little must be content to find himself left behind. Nay, so rapid is the progress, that scarce a geological work passes through the press in which some of the statements of the earlier pages have not to be modified, restricted, or extended in the concluding ones. The present volume shares, in this respect, in what seems the common lot. In describing the *Coccosteus*, the reader will find it stated that the creature, unlike its cotemporary the

Pterichthys, was unfurnished with arms. Ere arriving at such a conclusion I had carefully examined at least a hundred different *Coccostei;* but the positive evidence of one specimen outweighs the negative evidence of a hundred; and I have just learned from a friend in the north (Mr. Patrick Duff of Elgin), that a *Coccosteus* lately found at Lethen-bar, and now in the possession of Lady Gordon Cumming of Altyre, is furnished with what seem uncouth paddle-shaped arms, that project from the head.* All that I have given of the creature, however, will be found true to the actual type; and that parts should have been omitted will surprise no one who remembers that many hundred belemnites had been figured and described ere a specimen turned up in which the horny prolongation, with its enclosed ink bag, was found attached to the calcareous spindle; and that even yet, after many thousand trilobites have

* As these paddle-shaped arms have not been introduced by Agassiz into his restoration of the *Coccosteus*, their existence, at least *as arms*, must still be regarded as problematical. There can be no doubt, however, that they existed *as plates* of very peculiar form, and greatly resembling paddles, and that they served in the economy of the animal some still unaccounted for purpose.

been carefully examined, it remains a question with the oryctologist, whether this crustacean of the earliest periods was furnished with legs, or creeped on an abdominal foot, like the snail.

I owe to the kindness of Mr. Robertson, Inverugie, the specimen figured in Plate V., fig. 7, containing shells of the only species yet discovered in the Old Red Sandstone of Scotland. They occur in the Lower Formation of the system, in a quarry near Kirkwall, in which the specimen figured, with several others of the same kind, was found by Mr. Robertson in the year 1834. In referring to this shell, page 99,* I have spoken of it as a delicate bivalve, much resembling a *Venus;* drawing my illustration naturally enough, when describing the shell of an ocean deposit, rather from among marine than fluviatile testacea. I have since submitted it to Mr. Murchison, who has obligingly written me that he "can find no one to say more regarding it than that it is very like a *Cyclas.*" He adds, however, that it must be an ocean production notwithstanding, seeing that all its cotemporaries in England, Scotland, and

* Page 132 of the present edition.

Russia, whether shells or fish, are unequivocally marine.

With the exception of two of the figures in Plate IX., the figures of the *Cephalaspis* and the *Holoptychius*, and one of the sections in the Frontispiece, section 2, all the prints of the volume are originals. To Mr. Daniel Alexander of Edinburgh—a gentleman who to the skill and taste of the superior artist, adds no small portion of the knowledge of the practical geologist—I am indebted for several of the drawings; that of fig. 2 in Plate V., fig. 1 in Plate VI., fig. 2 in Plate VIII., and figs. 3 and 4 in Plate IX. I am indebted to another friend for fig. 1 in Plate VII. Whatever defects may be discovered in any of the others, must be attributed to the untaught efforts of the writer, all unfamiliar hitherto with the pencil, and with by much too little leisure to acquaint himself with it now.

CONTENTS.

CHAPTER I.

CHAPTER II.

CHAPTER III.

CHAPTER IV.

CHAPTER V.

CHAPTER VI.

CHAPTER VII.

CHAPTER VIII.

CHAPTER IX.

CHAPTER X.

CHAPTER XI.

CHAPTER XII.

CHAPTER XIII.

CHAPTER XIV.

DIRECTIONS TO THE BINDER.

Sheet of Sections to front Title Page.

Plate I.	to front page	78
II.	. . .	82
III.	. . .	84
IV.	. . .	104
V.	. . .	112
VI.	. . .	116
VII.	. . .	122
VIII.	. . .	124
IX.	. . .	182
X.	. . .	202

EXPLANATIONS OF THE SECTIONS AND PLATES.

SECTION I.

Represents the Old Red System of Scotland from its upper beds of Yellow Quartzose Sandstone to its Great Conglomerate base. *a*. Quartzose Yellow Sandstone. *b*. Impure concretionary limestone enclosing masses of chert. *c*. Red and variegated sandstones and conglomerate. These three deposits constitute an upper formation of the system, characterized by its peculiar group of fossils. (See Chapter IX.) *d*. Deposit of grey fissile sandstone which constitutes the middle formation of the system, characterized also by its peculiar organic group. (See Chapter VIII.) *e*. Red and variegated sandstones, undistinguishable often in their mineral character from the upper sandstones, *c*, but in general less gritty, and containing fewer pebbles. *f*. Bituminous schists. *g*. Coarse gritty sandstone. *h*. Great Conglomerate. These four beds compose a lower formation of the system, more strikingly marked by its peculiar organisms than even the other two. (See Chapters II. III. IV. and V.) In the section this lower formation is represented as we find it developed in Caithness and Orkney. In fig. 5 it is represented as developed in Cromarty, where, though the fossils are identical with those of the more northern localities, at least one of the deposits, *f*, is mineralogically different—alternating beds of sandstone and clay, these last enclosing limestone nodules, taking the place of the bituminous schists.

SECTION II.

The Old Red System of England and Wales, as given in the general Section of Mr. Murchison, with the Silurian Rocks be-

neath and the carboniferous limestone above. *i*. The point in the geological scale at which vertebrated existences first appear. The three Old Red Sandstone formations of this section correspond in their characteristic fossils with those of Scotland, but the proportions in which they are developed are widely different. The Tilestones seem a comparatively narrow stripe in the system in England: the answering formation in Scotland, *e*, *f*, *g*, *h*, is of such enormous thickness, that it has been held by very superior geologists to contain three distinct formations—*e*, the New Red Sandstone, *f*, a representative of the Coal Measures, and *g*, *h*, the Old Red Sandstone.

SECTION III.

Interesting case of extensive denudation from existing causes on the northern shore of the Moray Frith. (See pages 250 and 251.) The figures and letters which mark the various beds correspond with those of fig. 5, and of the following section. The "fish-bed," No. 1, represents what the reader will find described in pp. 277–281 as the "platform of sudden death."

SECTION IV.

Illustration of a fault in the Burn of Eathie, Cromartyshire. (See pages 257 and 258.)

Plate I.—Fig. 1. Restoration of upper side of the elongated species of *Pterichthys* (*P. Oblongus*) referred to in page 83. Fig. 2. *Pterichthys Milleri*. Fig. 3. Part of tail of elongated species, showing portions of the original covering of rhomboidal scales. Fig. 4. Tubercles of *Pterichthys* magnified.

Plate II.—Fig. 2. Restoration of under side of *Pterichthys Oblongus*. Fig. 1. A second specimen of *Pterichthys Milleri*. Fig. 3. Portion of wing, natural size.

Plate III.—Fig. 1. *Coccosteus Cuspidatus*. Fig. 2. Impression of inner surface of large dorsal plate. Fig. 3. Abdominal lozenge-shaped plate. Fig. 4. Portion of jaw with teeth.

Plate IV.—Fig. 1. Restoration of *Osteolepis major*. Fig. 2. Scales from the upper part of the body magnified. Fig. 3. Large

defensive scale which runs laterally along all the single fins. Fig. 4. Under side of scale, showing the attaching bar. Fig. 5. Enamelled and punctulated jaw of the creature. Fig. 6. Magnified portion of fin, showing the enamelled and punctulated rays.

Plate V.—Fig 1. *Dipterus macrolepidotus.* This figure serves merely to show the place of the fins, and the general outline of the ichthyolite. All the specimens the writer has hitherto examined fail to show the minuter details. Fig. 2. *Glyptolepis leptopterus.* Fig. 3. Single scale of the creature, showing its rustic style of ornament. Fig. 4. Scale with a nail-like attachment. Fig. 5. Under side of scale. Fig. 6. Magnified portion of fin. Fig. 7. Shells of the Old Red Sandstone.

Plate VI.—Fig. 1. *Cheirolepis Cummingiæ.* Fig. 2. Magnified scales. Fig. 3. Magnified portion of fin.

Plate VII.—Fig. 1. *Cheiracanthus microlepidotus.* Fig. 2. Magnified scales. Figs. 3, 4, 5, 6, 7, 8. Vegetable impressions of the Old Red Sandstone.

Plate VIII.—Fig. 1. *Diplacanthus longispinus.* Fig. 2. *Diplacanthus striatus.* Fig. 3. Magnified scales of fig. 1. Fig. 4. Spine of fig. 2, slightly magnified.

Plate IX.—Fig. 1. One of the tail flaps of the gigantic Crustacean of Forfarshire. Fig. 2. Reticulated markings of Carmylie.

Plate X.—Fig. 1. *Cephalaspis Lyellii*, copied from Lyell's *Elements of Geology.* Fig. 2. *Holoptychius Nobilissimus*, copied on a greatly reduced scale from Murchison's *Silurian System.* Fig. 3. Scale of *Holoptychius*, natural size. Fig. 4. Tooth of ditto, also natural size. These last drawn from specimens in the collection of Mr. Patrick Duff of Elgin.

NEW WALKS IN AN OLD FIELD;

OR,

THE OLD RED SANDSTONE.

CHAPTER I.

The Working-man's True Policy—His only Mode of acquiring Power—The Exercise of the Faculties essential to Enjoyment —No necessary connection between Labour and Unhappiness—Narrative—Scenes in a Quarry—The two Dead Birds—Landscape—Ripple Markings on a Sandstone Slab—Boulder Stones—Inferences derived from their water-worn Appearance—Sea-coast Section—My first-discovered Fossil—Lias Deposit on the Shores of the Moray Frith—Belemnite—Result of the Experience of half a Lifetime of Toil—Advantages of a Wandering Profession in connection with the Geology of a Country—Geological Opportunities of the Stone Mason—Design of the present Work.

My advice to young working men desirous of bettering their circumstances, and adding to the amount of their enjoyment, is a very simple one. Do not seek happiness in what is misnamed pleasure; seek it rather in what is termed study. Keep your consciences clear, your curiosity fresh, and embrace every opportunity of cultivating your minds. You will gain nothing by attending Chartist meetings. The fellows who

speak nonsense with fluency at these assemblies, and deem their nonsense eloquence, are totally unable to help either you or themselves; or, if they do succeed in helping themselves, it will be all at your expense. Leave them to harangue unheeded, and set yourselves to occupy your leisure hours in making yourselves wiser men. Learn to make a right use of your eyes: the commonest things are worth looking at—even stones and weeds, and the most familiar animals. Read good books, not forgetting the best of all: there is more true philosophy in the Bible than in every work of every sceptic that ever wrote; and we would be all miserable creatures without it, and none more miserable than you. You are jealous of the upper classes; and perhaps it is too true that, with some good, you have received much evil at their hands. It must be confessed they have hitherto been doing comparatively little for you, and a great deal for themselves. But upper and lower classes there must be, so long as the world lasts; and there is only one way in which your jealousy of them can be well directed. Do not let them get ahead of you in intelligence. It would be alike unwise and unjust to attempt casting them down to your own level, and no class would suffer more in the attempt than yourselves, for you would only be clearing the way, at an immense expense of blood, and under a tremendous pressure of misery, for another and perhaps worse aristocracy, with some second Cromwell or Napoleon at their head. Society, however, is in a state of continual flux: some in the upper classes are from time to time going down, and some of you from time to time

mounting up to take their places—always the more steady and intelligent among you, remember; and if all your minds were cultivated, not merely intellectually, but morally also, you would find yourselves, as a body, in the possession of a power which every charter in the world could not confer upon you, and which all the tyranny or injustice of the world could not withstand.

I intended, however, to speak rather of the pleasure to be derived, by even the humblest, in the pursuit of knowledge, than of the power with which knowledge in the masses is invariably accompanied. For it is surely of greater importance that men should receive accessions to their own happiness, than to the influence which they exert over other men. There is none of the intellectual, and none of the moral faculties, the exercise of which does not lead to enjoyment; nay, it is chiefly in the active employment of these that all enjoyment consists; and hence it is that happiness bears so little reference to station. It is a truth which has been often told, but very little heeded or little calculated upon, that though one nobleman may be happier than another, and one labourer happier than another, yet it cannot be at all premised of their respective orders, that the one is in any degree happier than the other. Simple as the fact may seem, if universally recognised, it would save a great deal of useless discontent, and a great deal of envy. Will my humbler readers permit me at once to illustrate this subject, and to introduce the chapters which follow, by a piece of simple narrative? I wish to show them how possible it is to enjoy much happiness in very mean employments. Cowper tell us that labour,

though the primal curse, "has been softened into mercy;" and I think that, even had he not done so, I would have found out the fact for myself.

It was twenty years last February since I set out a little before sunrise to make my first acquaintance with a life of labour and restraint, and I have rarely had a heavier heart than on that morning. I was but a slim, loose-jointed boy at the time—fond of the pretty intangibilities of romance, and of dreaming when broad awake; and, woful change! I was now going to work at what Burns has instanced in his "Twa Dogs," as one of the most disagreeable of all employments—to work in a quarry. Bating the passing uneasiness occasioned by a few gloomy anticipations, the portion of my life which had already gone by had been happy beyond the common lot. I had been a wanderer among rocks and woods—a reader of curious books when I could get them—a gleaner of old traditionary stories; and now I was going to exchange all my day-dreams, and all my amusements, for the kind of life in which men toil every day that they may be enabled to eat, and eat every day that they may be enabled to toil!

The quarry in which I wrought lay on the southern shore of a noble inland bay, or frith rather, with a little clear stream on the one side, and a thick fir wood on the other. It had been opened in the Old Red Sandstone of the district, and was overtopped by a huge bank of diluvial clay, which rose over it in some places to the height of nearly thirty feet, and which at this time was rent and shivered, wherever it presented an open front to the weather, by a recent

frost. A heap of loose fragments, which had fallen from above, blocked up the face of the quarry, and my first employment was to clear them away. The friction of the shovel soon blistered my hands, but the pain was by no means very severe, and I wrought hard, and willingly, that I might see how the huge strata below, which presented so firm and unbroken a frontage, were to be torn up and removed. Picks, and wedges, and levers, were applied by my brother-workmen; and simple and rude as I had been accustomed to regard these implements, I found I had much to learn in the way of using them. They all proved inefficient, however, and the workmen had to bore into one of the inferior strata, and employ gunpowder. The process was new to me, and I deemed it a highly amusing one: it had the merit, too, of being attended with some such degree of danger as a boating or rock excursion, and had thus an interest independent of its novelty. We had a few capital shots: the fragments flew in every direction; and an immense mass of the diluvium came toppling down, bearing with it two dead birds, that in a recent storm had crept into one of the deeper fissures, to die in the shelter. I felt a new interest in examining them. The one was a pretty cock goldfinch, with its hood of vermilion, and its wings inlaid with the gold to which it owes its name, as unsoiled and smooth as if it had been preserved for a museum. The other, a somewhat rarer bird, of the woodpecker tribe, was variegated with light blue and a greyish-yellow. I was engaged in admiring the poor little things, more disposed to be sentimental, perhaps, than

if I had been ten years older, and thinking of the contrast between the warmth and jollity of their green summer haunts, and the cold and darkness of their last retreat, when I heard our employer biddin the workmen lay by their tools. I looked up and saw the sun sinking behind the thick fir wood beside us, and the long dark shadows of the trees stretching downwards towards the shore.

This was no very formidable beginning of the course of life I had so much dreaded. To be sure, my hands were a little sore, and I felt nearly as much fatigued as if I had been climbing among the rocks; but I had wrought and been useful, and had yet enjoyed the day fully as much as usual. It was no small matter, too, that the evening, converted, by a rare transmutation, into the delicious "blink of rest" which Burns so truthfully describes, was all my own. I was as light of heart next morning as any of my brother-workmen. There had been a smart frost during the night, and the rime lay white on the grass as we passed onwards through the fields; but the sun rose in a clear atmosphere, and the day mellowed, as it advanced, into one of those delightful days of early spring, which give so pleasing an earnest of whatever is mild and genial in the better half of the year. All the workmen rested at mid-day, and I went to enjoy my half-hour alone on a mossy knoll in the neighbouring wood, which commands through the trees a wide prospect of the bay and the opposite shore. There was not a wrinkle on the water, nor a cloud in the sky, and the branches were as moveless in the calm as it they had been traced on canvass.

From a wooded promontory that stretched half-way across the frith, there ascended a thin column of smoke. It rose straight as the line of a plummet for more than a thousand yards, and then, on reaching a thinner stratum of air, spread out equally on every side like the foliage of a stately tree. Ben Wevis rose to the west, white with the yet unwasted snows of winter, and as sharply defined in the clear atmosphere, as if all its sunny slopes and blue retiring hollows had been chiselled in marble. A line of snow ran along the opposite hills; all above was white, and all below was purple. They reminded me of the pretty French story, in which an old artist is described as tasking the ingenuity of his future son-in-law, by giving him as a subject for his pencil a flower-piece composed of only white flowers, of which the one-half were to bear their proper colour, the other half a deep purple hue, and yet all be perfectly natural; and how the young man resolved the riddle and gained his mistress, by introducing a transparent purple vase into the picture, and making the light pass through it on the flowers that were drooping over the edge. I returned to the quarry, convinced that a very exquisite pleasure may be a very cheap one, and that the busiest employments may afford leisure enough to enjoy it.

The gunpowder had loosened a large mass in one of the inferior strata, and our first employment, on resuming our labours, was to raise it from its bed. I assisted the other workmen in placing it on edge, and was much struck by the appearance of the platform on which it had rested. The entire surface was

ridged and furrowed like a bank of sand that had been left by the tide an hour before. I could trace every bend and curvature, every cross hollow and counter ridge of the corresponding phenomena; for the resemblance was no half resemblance—it was the thing itself; and I had observed it a hundred and a hundred times, when sailing my little schooner in the shallows left by the ebb. But what had become of the waves that had thus fretted the solid rock, or of what element had they been composed, I felt as completely at fault as Robinson Crusoe did on his discovering the print of the man's foot on the sand. The evening furnished me with still further cause of wonder. We raised another block in a different part of the quarry, and found that the area of a circular depression in the stratum below was broken and flawed in every direction, as if it had been the bottom of a pool recently dried up, which had shrunk and split in the hardening. Several large stones came rolling down from the diluvium in the course of the afternoon. They were of different qualities from the Sandstone below, and from one another; and, what was more wonderful still, they were all rounded and water-worn, as if they had been tossed about in the sea, or the bed of a river, for hundreds of years. There could not, surely, be a more conclusive proof that the bank which had enclosed them so long could not have been created on the rock on which it rested. No workman ever manufactures a half-worn article, and the stones were all half-worn! And if not the bank, why then the sandstone underneath? I was lost in conjecture, and found I had food enough for

thought that evening, without once thinking of the unhappiness of a life of labour.

The immense masses of diluvium which we had to clear away rendered the working of the quarry laborious and expensive, and all the party quitted it in a few days, to make trial of another that seemed to promise better. The one we left is situated, as I have said, on the southern shore of an inland bay—the Bay of Cromarty; the one to which we removed has been opened in a lofty wall of cliffs that overhangs the northern shore of the Moray Frith. I soon found I was to be no loser by the change. Not the united labours of a thousand men for more than a thousand years could have furnished a better section of the geology of the district than this range of cliffs. It may be regarded as a sort of chance dissection on the earth's crust. We see in one place the primary rock, with its veins of granite and quartz, its dizzy precipices of gneiss, and its huge masses of horneblend; we find the secondary rock in another, with its beds of sandstone and shale, its spars, its clays, and its nodular limestones. We discover the still little-known but highly interesting fossils of the Old Red Sandstone in one deposition; we find the beautifully-preserved shells and lignites of the Lias in another. There are the remains of two several creations at once before us. The shore, too, is heaped with rolled fragments of almost every variety of rock,—basalts, ironstones, hyperstenes, porphyries, bituminous shales, and micaceous schists. In short, the young geologist, had he all Europe before him, could hardly choose for himself a better field. I had, how-

ever, no one to tell me so at the time, for geology had not yet travelled so far north; and so, without guide or vocabulary, I had to grope my way as I best might, and find out all its wonders for myself. But so slow was the process, and so much was I a seeker in the dark, that the facts contained in these few sentences were the patient gatherings of years.

In the course of the first day's employment, I picked up a nodular mass of blue limestone, and laid it open by a stroke of the hammer. Wonderful to relate, it contained inside a beautifully-finished piece of sculpture—one of the volutes apparently of an Ionic capital; and not the far-famed walnut of the fairy tale, had I broken the shell and found the little dog lying within, could have surprised me more. Was there another such curiosity in the whole world? I broke open a few other nodules of similar appearance—for they lay pretty thickly on the shore—and found that there might. In one of these there were what seemed to be the scales of fishes, and the impressions of a few minute bivalves, prettily striated; in the centre of another there was actually a piece of decayed wood. Of all Nature's riddles these seemed to me to be at once the most interesting, and the most difficult to expound. I treasured them carefully up, and was told by one of the workmen to whom I showed them, that there was a part of the shore about two miles farther to the west, where curiously-shaped stones, somewhat like the heads of boarding-pikes, were occasionally picked up; and that in his father's days the country people called them thunder-bolts, and deemed them of sovereign efficacy in curing bewitched cattle.

Our employer, on quitting the quarry for the building on which we were to be engaged, gave all the workmen a half-holiday. I employed it in visiting the place where the thunder-bolts had fallen so thickly, and found it a richer scene of wonder than I could have fancied in even my dreams.

What first attracted my notice was a detached group of low-lying skerries, wholly different in form and colour from the sandstone cliffs above, or the primary rocks a little farther to the west. I found them composed of thin strata of limestone, alternating with thicker beds of a black slaty substance, which, as I ascertained in the course of the evening, burns with a powerful flame, and emits a strong bituminous odour. The layers into which the beds readily separate are hardly an eighth part of an inch in thickness, and yet on every layer there are the impressions of thousands and tens of thousands of the various fossils peculiar to the Lias. We may turn over these wonderful leaves one after one, like the leaves of a herbarium, and find the pictorial records of a former creation in every page. Scallops, and gryphites, and ammonites, of almost every variety peculiar to the formation, and at least some eight or ten varieties of belemnite; twigs of wood, leaves of plants, cones of an extinct species of pine, bits of charcoal, and the scales of fishes; and, as if to render their pictorial appearance more striking, though the leaves of this interesting volume are of a deep black, most of the impressions are of a chalky whiteness. I was lost in admiration and astonishment, and found my very imagination paralyzed by an assemblage of wonders,

that seemed to outrival, in the fantastic and the extravagant, even its wildest conceptions. I passed on from ledge to ledge, like the traveller of the tale through the city of statues, and at length found one of the supposed aërolites I had come in quest of, firmly imbedded in a mass of shale. But I had skill enough to determine that it was other than what it had been deemed. A very near relative, who had been a sailor in his time on almost every ocean, and had visited almost every quarter of the globe, had brought home one of these meteoric stones with him from the coast of Java. It was of a cylindrical shape and vitreous texture, and it seemed to have parted in the middle when in a half-molten state, and to have united again, somewhat awry, ere it had cooled enough to have lost the adhesive quality. But there was nothing organic in its structure, whereas the stone I had now found was organized very curiously indeed. It was of a conical form and filamentary texture, the filaments radiating in straight lines from the centre to the circumference. Finely-marked veins like white threads ran transversely through these in its upper half to the point, while the space below was occupied by an internal cone, formed of plates that lay parallel to the base, and which, like watch-glasses, were concave on the under side, and convex on the upper. I learned in time to call this stone a belemnite, and became acquainted with enough of its history to know that it once formed part of a variety of cuttle-fish, long since extinct.

My first year of labour came to a close, and I found that the amount of my happiness had not been less

than in the last of my boyhood. My knowledge, too, had increased in more than the ratio of former seasons; and as I had acquired the skill of at least the common mechanic, I had fitted myself for independence. The additional experience of twenty years has not shown me that there is any necessary connection between a life of toil and a life of wretchedness; and when I have found good men anticipating a better and a happier time than either the present or the past, the conviction that in every period of the world's history the great bulk of mankind must pass their days in labour, has not in the least inclined me to scepticism.

My curiosity, once fully awakened, remained awake, and my opportunities of gratifying it have been tolerably ample. I have been an explorer of caves and ravines—a loiterer along sea-shores—a climber among rocks—a labourer in quarries. My profession was a wandering one. I remember passing direct, on one occasion, from the wild western coast of Ross-shire, where the Old Red Sandstone leans at a high angle against the prevailing Quartz Rock of the district, to where, on the southern skirts of Mid-Lothian, the Mountain Limestone rises amid the coal. I have resided one season on a raised beach of the Moray Frith. I have spent the season immediately following amid the ancient granites and contorted schists of the central Highlands. In the north I have laid open by thousands the shells and lignites of the Oolite; in the south I have disinterred from their matrices of stone or of shale the huge reeds and tree ferns of the Carboniferous period. I have been taught by experi-

ence, too, how necessary an acquaintance with the geology of both extremes of the kingdom is to the right understanding of the formations of either. In the north, there occurs a vast gap in the scale. The Lias leans unconformably against the Old Red Sandstone; there is no Mountain Limestone, no Coal Measures, none of the New Red Marls or Sandstones, Under or Upper. There are at least three entire systems omitted. But the upper portion of the scale is well-nigh complete. In one locality we may pass from the Lower to the Upper Lias, in another from the Inferior to the Great Oolite, and onward to the Oxford Clay and the Coral Rag. We may explore in a third locality, beds identical in their organisms with the Wealden of Sussex. In a fourth we find the flints and fossils of the Chalk. The lower part of the scale is also well-nigh complete. The Old Red Sandstone is amply developed in Moray, Caithness, and Ross, and the Grauwacke more ancient unfossiliferous type rather extensively in Banffshire. But to acquaint one's self with the three missing formations—to complete one's knowledge of the entire scale by filling up the hiatus—it is necessary to remove to the south. The geology of the Lothians is the geology of at least two-thirds of the gap, and perhaps a little more;—the geology of Arran wants, it is supposed, only the Upper New Red Sandstone to fill it entirely.

One important truth I would fain press on the attention of my lowlier readers. There are few professions, however humble, that do not present their peculiar advantages of observation; there are none, I repeat, in which the exercise of the faculties does not

lead to enjoyment. I advise the stone-mason, for instance, to acquaint himself with Geology. Much of his time must be spent amid the rocks and quarries of widely separated localities. The bridge or harbour is no sooner completed in one district than he has to remove to where the gentleman's seat or farm-steading is to be erected in another; and so, in the course of a few years, he may pass over the whole geological scale, even when restricted to Scotland, from the Grauwacke of the Lammermuirs, to the Wealden of Moray or the Chalk-flints of Banffshire and Aberdeen; and this, too, with opportunities of observation, at every stage, which can be shared with him by only the gentleman of fortune, who devotes his whole time to the study. Nay, in some respects, his advantages are superior to those of the amateur himself. The latter must often pronounce a formation unfossiliferous when, after the examination of at most a few days, he discovers in it nothing organic; and it will be found that half the mistakes of geologists have arisen from conclusions thus hastily formed. But the working man, whose employments have to be carried on in the same formation for months, perhaps years together, enjoys better opportunities for arriving at just decisions. There are, besides, a thousand varieties of accident which lead to discovery—floods, storms, landslips, tides of unusual height, ebbs of extraordinary fall: and the man who plies his labour at all seasons in the open air has by much the best chance of profiting by these. There are formations which yield their organisms slowly to the discoverer, and the proofs which establish their place in the geological scale more tardily

still.* I was acquainted with the Old Red Sandstone of Ross and Cromarty for nearly ten years ere I had ascertained that it is richly fossiliferous—a discovery which, in exploring this formation in those localities, some of our first geologists had failed to anticipate: I was acquainted with it for nearly ten years more ere I could assign to its fossils their exact place in the scale.

In the following chapters I shall confine my observations chiefly to this system and its organisms. To none of the others, perhaps, excepting the Lias of the north of Scotland, have I devoted an equal degree of attention; nor is there a formation among them which, up to the present time, has remained so much a *terra incognita* to the geologist. The space on both sides has been carefully explored to its upper and lower boundary; the space between has been suffered to remain well-nigh a chasm. Should my facts regarding it—facts constituting the slow gatherings of years—serve as stepping-stones laid across, until such time as geologists of greater skill and more extended research shall have bridged over the gap, I shall have completed half my design. Should the working man be encouraged by my modicum of success to improve his opportunities of observation, I shall have accomplished the whole of it. It cannot be too extensively known, that nature is vast and knowledge limited, and that no individual, however humble in place or acquirement, need despair of adding to the general fund.

CHAPTER II.

The Old Red Sandstone—Till very lately its Existence as a distinct Formation disputed—Still little known—Its great Importance in the Geological Scale—Illustration—The North of Scotland girdled by an immense Belt of Old Red Sandstone—Line of the Girdle along the Coast—Marks of vast Denudation—Its Extent partially indicated by Hills on the Western Coast of Ross-shire—The System of great Depth in the North of Scotland—Difficulties in the way of estimating the Thickness of Deposits—Peculiar Formation of Hill—Illustrated by Ben Nevis—Caution to the Geological Critic—Lower Old Red Sandstone immensely developed in Caithness—Sketch of the Geology of that County—Its strange Group of Fossils—Their present place of Sepulture—Their ancient Habitat—Agassiz—Amazing Progress of Fossil Ichthyology during the last few Years—Its Nomenclature—Learned names repel unlearned Readers—Not a great deal in them.

"THE Old Red Sandstone," says a Scottish geologist, in a digest of some recent geological discoveries, which appeared a short time ago in an Edinburgh newspaper, "has been hitherto considered as remarkably barren of fossils." The remark is expressive ot a pretty general opinion among geologists of even the present time, and I quote it on this account. Only a few years have gone by since men of no low standing in the science disputed the very existence of this formation—system rather, for it contains at least three

distinct formations; and but for the influence of one accomplished geologist, the celebrated author of the *Silurian System*, it would have been probably degraded from its place in the scale altogether. "You must inevitably give up the Old Red Sandstone," said an ingenious foreigner to Mr. Murchison, when on a visit to England about four years ago, and whose celebrity among his own countrymen rested chiefly on his researches in the more ancient formations—"you must inevitably give up the Old Red Sandstone: it is a mere local deposit, a doubtful accumulation huddled up in a corner, and has no type or representative abroad." "I would willingly give it up if nature would," was the reply; "but it assuredly exists, and I cannot." In a recently published tabular exhibition of the geological scale by a continental geologist, I could not distinguish this system at all. There are some of our British geologists, too, who still regard it as a sort of debatable tract, entitled to no independent status. They find, in what they deem its upper beds, the fossils of the Coal Measures, and the lower graduating apparently into the Silurian System; and regard the whole as a sort of common, which should be divided as proprietors used to divide commons in Scotland half a century ago, by giving a portion to each of the bordering territories. Even the better-informed geologists, who assign to it its proper place as an independent formation, furnished with its own organisms, contrive to say all they know regarding it in a very few paragraphs. Lyell, in the first edition of his admirable elementary work, published only two years ago, devotes more than thirty pages to his de-

scription of the Coal Measures, and but two and a half to his notice of the Old Red Sandstone.*

* As the succinct notice of this distinguished geologist may serve as a sort of pocket map to the reader in indicating the position of the system, its three great deposits, and its extent, I take the liberty of transferring it entire.

"OLD RED SANDSTONE.

"It was stated that the Carboniferous formation was surmounted by one called the 'New Red Sandstone,' and underlaid by another called the Old Red, which last was formerly merged in the Carboniferous System, but is now found to be distinguishable by its fossils. The Old Red Sandstone is of enormous thickness in Herefordshire, Worcestershire, Shropshire, and South Wales, where it is seen to crop out beneath the Coal Measures, and to repose on the Silurian Rocks. In that region, its thickness has been estimated by Mr. Murchison at no less than ten thousand feet. It consists there of

"1*st*, a quartzose conglomerate passing downwards into chocolate-red and green sandstone and marl.

"2*d*, Cornstone and marl (red and green argillaceous spotted marls, with irregular courses of impure concretionary limestone, provincially called Cornstone, mottled red and green; remains of fishes).

"3*d*, Tilestone (finely laminated hard reddish or green micaceous or quartzose sandstones, which split into tiles; remains of mollusca and fishes).

"I have already observed that fossils are rare in marls and sandstones, in which the red oxide of iron prevails. In the Cornstone, however, of the counties above-mentioned fishes of the genera Cephalaspis and Onchus have been discovered. In the Tilestone also, Ichthyodorulites of the genus Onchus have been obtained, and a species of Dipterus, with mollusca of the genera Avicula, Arca, Cucullæa, Terebratula, Lingula, Turbo, Trochus, Turritella, Bellerophon, Orthoceras, and others.

"By consulting geological maps, the reader will perceive that from Wales to the north of Scotland the Old Red Sandstone appears in patches, and often in large tracts. Many fishes have been found in it at Caithness, and various organic remains in the northern part of Fifeshire, where it crops out from beneath the

It will be found, however, that this hitherto neglected system yields in importance to none of the others, whether we take into account its amazing depth, the great extent to which it is developed both at home and abroad, the interesting links which it furnishes in the zoological scale, or the vast period of time which it represents. There are localities in which the depth of the Old Red Sandstone fully equals the elevation of Mount Etna over the level of the sea, and in which it contains three distinct groups of organic remains, the one rising in beautiful progression over the other. Let the reader imagine a digest of English history, complete from the times of the invasion of Julius Cæsar to the reign of that Harold who was slain at Hastings, and from the times of Edward III. down to the present day, but bearing no record of the Williams, the Henrys, the Edwards,

Coal formation, and spreads into the adjoining northern half of Forfarshire; forming, together with trap, the Sidlaw Hills and valley of Strathmore. A large belt of this formation skirts the northern borders of the Grampians, from the sea-coast at Stonehaven and the Frith of Tay, to the opposite western coast of the Frith of Clyde. In Forfarshire, where, as in Herefordshire, it is many thousand feet thick, it may be divided into three principal masses; *1st*, Red and mottled marls, cornstone, and sandstone; *2d*, Conglomerate, often of vast thickness; *3d*, Tilestones, and paving stone, highly micaceous, and containing a slight admixture of carbonate of lime. In the uppermost of these divisions, but chiefly in the lowest, the remains of fish have been found of the genus named by M. Agassiz Cephalaspis, or buckler-headed, from the extraordinary shield which covers the head, and which has often been mistaken for that of a trilobite of the division Asaphus. A gigantic species of fish of the genus Holoptychius has also been found by Dr. Fleming in the Old Red Sandstone of Fifeshire."—Lyell's *Elements*, pp. 452, 3, 4.

the John, Stephen, and Richard, that reigned during the omitted period, or of the striking and important events by which their several reigns were distinguished. A chronicle thus mutilated and incomplete would be no unapt representation of a geological history of the earth in which the period of the Upper Silurian would be connected with that of the Mountain Limestone, or of the limestone of Burdie House, and the period of the Old Red Sandstone omitted.

The eastern and western coasts of Scotland, which lie to the north of the Friths of Forth and Clyde, together with the southern flank of the Grampians and the northern coast of Sutherland and Caithness, appear to have been girdled at some early period by immense continuous beds of Old Red Sandstone. At a still earlier time the girdle seems to have formed an entire mantle, which covered the enclosed tract from side to side. The interior is composed of what, after the elder geologists, I shall term primary rocks—porphyries, granites, gneisses, and micaceous schists; and this central nucleus, as it now exists, seems set in a sandstone frame. The southern bar of the frame is still entire: it stretches along the Grampians from Stonehaven to the Frith of Clyde. The northern bar is also well-nigh entire: it runs unbroken along the whole northern coast of Caithness, and studs in three several localities the northern coast of Sutherland, leaving breaches of no very considerable extent between. On the east there are considerable gaps, as along the shores of Aberdeenshire.* The sandstone,

* The progress of discovery has shown, since this passage was written, that these gaps are not quite so considerable as I had

however, appears at Gamrie, in the county of Banff, in a line parallel to the coast, and, after another interruption, follows the course of the Moray Frith far-

supposed. The following paragraph, which appeared in July 1843, in an Aberdeen paper, bears directly on the point, and is worthy of being preserved:—

"ARTESIAN WELL.

"The greatest of these interesting works yet existing in Aberdeen has just been successfully completed, at the tape works of Messrs. Milne, Low, & Co., Woolmanhill. The bore is 8 inches in diameter, and 250 feet 9 inches deep. It required nearly eleven months' working to complete the excavation.

In its progress the following strata were cut through in succession:—

6 feet		vegetable mould.
18	,,	grey or bluish clay.
20	,,	sand and shingle, enclosing rolled stones of various sizes.
6	,,	light blue clay
3	,,	rough sand and shingle.
115	,,	Old Red Sandstone conglomerate, composed of red clay, quartz, mica, and rolled stones.
74	,,	alternating strata of compact fine-grained Red Sandstone, varying in thickness from 1 to 7 feet, and clay varying from 6 inches to 12 feet thick.
8	,,	9 inches, mica-slate formation, the first two feet of which were chiefly a hard brown quartzose substance, containing iron, manganese, and carbonate of lime.
250 feet 9 inches.		

"The temperature of the water at the bottom of the well when completed, was found to be within a fraction of 50° Fahrenheit, and the average temperature of the locality, deduced from twenty-three years' observation, by the late George Innes, F.R.S., is 47° 1—hence nearly 3 degrees of increase appear as the effects of central heat. The supply of water obtained is excellent in quality, and sufficient in quantity for all the purposes of the works. Such an opportunity of investigating the geology of the locality can but rarely occur; and in the present instance the proprietor and managers afforded every facility to scientific inquirers for conducting examinations. To make the bearings of the case clear and simple, the following is quoted from Mr. Miller's work

into the interior of the great Caledonian valley, and then running northward along the shores of Cromarty, Ross, and Sutherland, joins, after another brief interruption, the northern bar at Caithness. The western bar has also its breaches towards the south; but it stretches almost without interruption for about a hundred miles from the near neighbourhood of Cape Wrath to the southern extremity of Applecross; and though greatly disturbed and overflown by the traps of the inner Hebrides, it can be traced by occasional patches on towards the southern bar. It appears on the northern shore of Loch Alsh, on the eastern shore of Loch Eichart, on the southern shore of Loch Eil, on the coast and islands near Oban, and on the east coast of Arran. Detached hills and island-like patches of the same formation occur in several parts of the interior, far within the frame or girdle. It

on the Old Red Sandstone. [The writer here quotes the above passage, and then proceeds.] Mr. Miller will be glad to learn, that though the convulsions of nature have shattered the 'frame' along the shores of Aberdeenshire, yet the fragments are not lost, as will be seen from the section above described; they are here reposing *in situ* under the accumulated debris of uncounted ages—chiefly the 'boulder clay,' and sedimentary deposits of the Dee and Don, during a period when they mingled their waters in the bason in which Aberdeen now stands. The primary rocks —the settings—our granites of matchless beauty—stand out in bold relief a mile or two westward from the sea-coast. Within this year or two the 'Old Red' has been discovered at Devanha, Union Grove, Huntly Street, Glenburnie, Balgownie, and various other localities to the northward. Hence it may reasonably be inferred, that our fragment of the 'frame' envelops the primary rocks under our city, and along the coast for a considerable distance between the Dee and the Buchaness."—*Aberdeen Constitutional.*

caps some of the higher summits in Sutherlandshire; it forms an oasis of sandstone among the primary districts of Strathspey; it rises on the northern shores of Loch Ness in an immense mass of conglomerate, based on a small-grained red granite, to a height of about three thousand feet over the level; and on the north-western coast of Ross-shire it forms three immense insulated hills, of at least no lower altitude, that rest unconformably on a base of gneiss.

There appear everywhere in connection with these patches and eminences, and with the surrounding girdle, marks of vast denudation. I have often stood fronting the three Ross-shire hills* at sun-set in the finer summer evenings, when the clear light threw the shadows of their gigantic cone-like forms far over the lower tract, and lighted up the lines of their horizontal strata, till they showed like courses of masonry in a pyramid. They seem at such times as if coloured by the geologist, to distinguish them from the surrounding tract, and from the base on which they rest as on a common pedestal. The prevailing gneiss of the district reflects a cold bluish hue, here and there speckled with white, where the weathered and lichened crags of intermingled Quartz-rock jut out on the hill-sides from among the heath. The three huge pyramids, on the contrary, from the deep red of the stone, seem flaming in purple. There spreads all around a wild and desolate landscape of broken and shattered hills, separated by deep and gloomy ravines, that seem the rents and fissures of a planet in ruins, and that speak distinctly of a period of convulsion, when up-

* Suil Veinn, Coul Beg, and Coul More.

heaving fires from the abyss, and ocean-currents above, had contended in sublime antagonism, the one slowly elevating the entire tract, the other grinding it down and sweeping it away. I entertain little doubt, that when this loftier portion of Scotland, including the entire Highlands, first presented its broad back over the waves, the upper surface consisted exclusively, from the one extremity to the other—from Benlomond to the Maidenpaps of Caithness—of a continuous tract of Old Red Sandstone, though, ere the land finally emerged, the ocean-currents of ages had swept it away, all except in the lower and last-raised borders, and in the detached localities, where it still remains, as in the pyramidal hills of Western Ross-shire, to show the amazing depth to which it had once overlaid the inferior rocks. The Old Red Sandstone of Morvheim in Caithness overlooks all the primary hills of the district, from an elevation of three thousand five hundred feet.

The depth of the system, on both the eastern and western coasts of Scotland, is amazingly great—how great I shall not venture to say. There are no calculations more doubtful than those of the geologist. The hill just instanced (Morvheim) is apparently composed from top to bottom of what in Scotland forms the lowest member of the system—a coarse conglomerate; and yet I have nowhere observed this inferior member, when I succeeded in finding a section of it directly vertical, more than a hundred yards in thickness—less than one-tenth the height of the hill. It would be well-nigh as unsafe to infer that the three thousand five hundred feet of altitude formed the

real thickness of the conglomerate, as to infer that the thickness of the lead which covers the dome of St. Paul's is equal to the height of the dome. It is always perilous to estimate the depth of a deposit by the height of a hill that seems externally composed of it, unless, indeed, like the pyramidal hills of Ross-shire, it be unequivocally a hill dug out by denudation, as the sculptor digs his eminences out of the mass. In most of our hills the upheaving agency has been actively at work, and the space within is occupied by an immense nucleus of inferior rock, around which the upper formation is wrapped like a caul, just as the vegetable mould or the diluvium wraps up this superior covering in turn. One of our best known Scottish mountains—the gigantic Ben Nevis—furnishes an admirable illustration of this latter construction of hill. It is composed of three zones or rings of rock, the one rising over and out of the other, like the cases of an opera-glass drawn out. The lower zone is composed of gneiss and mica-slate—the middle zone of granite—the terminating zone of porphyry. The elevating power appears to have acted in the centre, as in the well-known case of Jorullo, in the neighbourhood of the city of Mexico, where a level tract four square miles in extent rose, about the middle of the last century, into a high dome of more than double the height of Arthur's Seat.*

* It is rarely that the geologist catches a hill in the act of forming, and hence the interest of this well-attested instance. From the period of the discovery of America to the middle of the last century, the plains of Jorullo had undergone no change of surface, and the seat of the present hill was covered by plantations of indigo and sugar cane, when, in June 1759, hollow sounds were

In the formation of our Scottish mountain, the gneiss and mica-slate of the district seem to have been upheaved, during the first period of Plutonic action in the locality, into a rounded hill of moderate altitude, but of huge base. The upheaving power continued to operate—the gneiss and mica-slate gave way atop—and out of this lower dome there arose a higher dome of granite, which in an after and terminating period of the internal activity, gave way in turn to yet a third and last dome of porphyry. Now, had the elevating forces ceased to operate just ere the gneiss and mica-slate had given way, we would have known nothing of the interior nucleus of granite—had they ceased just ere the granite had given way,

heard, and a succession of earthquakes continued for sixty days, to the great consternation of the inhabitants. After the cessation of these, and in a period of tranquillity, on the 28th and 29th September, a horrible subterranean noise was again heard, and a tract four square miles in extent rose up, in the shape of a dome or bladder, to the height of sixteen hundred and seventy feet above the original level of the plain. The affrighted Indians fled to the mountains; and from thence looking down on the phenomenon, saw flames issuing from the earth for miles around the newly-elevated hill, and the softened surface rising and falling like that of an agitated sea, and opening into numerous rents and fissures. Two brooks which had watered the plantations precipitated themselves into the burning chasms. The scene of this singular event was visited by Humboldt about the beginning of the present century. At that period the volcanic agencies had become comparatively quiescent; the hill, however, retained its original altitude; a number of smaller hills had sprung up around it; and the traveller found the waters of the engulfed rivulets escaping at a high temperature from caverns charged with sulphureous vapours and carbonic acid gas. There were inhabitants of the country living at the time who were more than twenty years older than the hill of Jorullo, and who had witnessed its rise.

we would have known nothing of the yet deeper nucleus of porphyry; and yet the granite and the porphyry would assuredly have been there. Nor could any application of the measuring rule to the side of the hill have ascertained the thickness of its outer covering—the gneiss and the mica schist. The geologists of the school of Werner used to illustrate what we may term the anatomy of the earth, as seen through the spectacles of their system, by an onion and its coats: they represented the globe as a central nucleus, encircled by concentric coverings, each covering constituting a geological formation. The onion, through the introduction of a better school, has become obsolete as an illustration; but to restore it again, though for another purpose, we have merely to cut it through the middle, and turn downwards the planes formed by the knife. It then represents, with its coats, two such hills as we describe—hills such as Ben Nevis, ere the granite had perforated the gneiss, or the porphyry broken through the granite.

If it be thus unsafe, however, to calculate on the depth of deposits by the altitude of hills, it is quite as unsafe for the geologist who has studied a formation in one district, to set himself to criticise the calculations of a brother geologist by whom it has been studied in a different and widely-separated district. A deposit in one locality may be found to possess many times the thickness of the same deposit in another. There are exposed, beside the Northern and Southern Sutors of Cromarty, two nearly vertical sections of the coarse conglomerate bed, which forms, as I have said, in the north of Scotland, the base of the

Old Red System, and which rises to so great an elevation in the mountain of Morvheim. The sections are little more than a mile apart; and yet, while the thickness of this bed in the one does not exceed one hundred feet, that of the same bed in the other somewhat exceeds two hundred feet. More striking still—under the Northern Sutor, the entire Geology of Caithness, with all its vast beds, and all its numerous fossils, from the granitic rock of the Ord hill, the southern boundary of the county, to the uppermost sandstones of Dunnet-head, its extreme northern corner, is exhibited in a vertical section not more than three hundred yards in extent. And yet so enormous is the depth of the deposit in Caithness, that it has been deemed by very superior geologists to represent three entire formations—the Old Red System, by its unfossiliferous, arenaceous, and conglomerate beds; the Carboniferous System, by its dark-coloured middle schists, abounding in bitumen and ichthyolites; and the New Red Sandstone, by the mottled marls and mouldering sandstones that overlie the whole.* A slight sketch of the Geology of Caithness may not be

* Dr. Hibbert, whose researches among the limestones of Burdie House have been of such importance to Geology, was of this opinion. I find it also expressed in the admirable geological appendix affixed by the Messrs. Anderson to their *Guide to the Highlands and Islands of Scotland.* "No beds of real coal," say these gentlemen, "have been discovered in Caithness; and it would thus appear that the middle schistose system of the county, containing the fossil fish, is in geological character and position intermediate between the Old and New Red Sandstone formations, but not identical with the Carboniferous Limestone or the true Coal Measures, although probably occupying the place of one or other of them."—P. 198.

deemed uninteresting. This county includes, in the state of greatest development anywhere yet known, that fossiliferous portion of the Old Red Sandstone which I purpose first to describe, and which will yet come to be generally regarded as an independent formation, as unequivocally characterized by its organic remains as the formations either above or below it.

The county of Sutherland stretches across the island from the German to the Atlantic Ocean, and presents, throughout its entire extent—except where a narrow strip of the Oolitic formation runs along its eastern coast, and a broken belt of Old Red Sandstone tips its capes and promontories on the west—a broken and tumultuous sea of primary hills. Scarce any of our other Scottish counties are so exclusively Highland, nor are there any of them in which the precipices are more abrupt, the valleys more deep, the rivers more rapid, or the mountains piled into more fantastic groups and masses. The traveller passes into Caithness, and finds himself surrounded by scenery of an aspect so entirely dissimilar, that no examination of the rocks is necessary to convince him of a geological difference of structure. An elevated and uneven plain spreads around and before him, league beyond league, in tame and unvaried uniformity—its many hollows darkened by morasses, over which the intervening eminences rise in the form rather of low moory swellings, than of hills—its coasts walled round by cliffs of gigantic altitude, that elevate the district at one huge stride from the level of the sea, and skirted by vast stacks and columns of rock, that stand out like the advanced picquets of the land

amid the ceaseless turmoil of the breakers. The district, as shown on the map, presents nearly a triangular form—the Pentland Frith and the German Ocean describing two of its sides, while the base is formed by the line of boundary which separates it from the county of Sutherland.

Now, in a geological point of view, this angle may be regarded as a vast pyramid, rising perpendicularly from the basis furnished by the primary rocks of the latter county, and presenting newer beds and strata as we ascend, until we reach the apex. The line from south to north in the angle — from Morvheim to Dunnet-head—corresponds to the line of ascent from the top to the bottom of the pyramid. The first bed, reckoning from the base upwards—the ground tier of the masonry, if I may so speak—is the great conglomerate. It runs along the line of boundary from sea to sea—from the Ord of Caithness on the east, to Portskerry on the north; and rises, as it approaches the primary hills of Sutherland, into a lofty mountain-chain of bold and serrated outline, which attains its greatest elevation in the hill of Morvheim. This great conglomerate bed, the base of the system, is represented in the Cromarty section, under the Northern Sutor, by a bed two hundred and fifteen feet in thickness. The second tier of masonry in the pyramid, and which also runs in a nearly parallel line from sea to sea, is composed mostly of a coarse red and yellowish sandstone, with here and there beds of pebbles enclosed, and here and there deposits of green earth and red marl. It has its representative in the Cromarty section, in a bed of red and yellow arena-

ceous stone, one hundred and fourteen feet six inches in thickness. These two inferior beds possess but one character—they are composed of the same materials, with merely this difference, that the rocks which have been broken into pebbles for the construction of the one, have been ground into sand for the composition of the other. Directly over them the middle portion of the pyramid is occupied by an enormous deposit of dark-coloured bituminous schist, slightly micaceous, calcareous, or semi-calcareous—here and there interlaced with veins of carbonate of lime—here and there compact and highly siliceous—and bearing in many places a mineralogical character difficult to be distinguished from that at one time deemed peculiar to the harder grauwacke schists. The Caithness flagstones, so extensively employed in paving the footways of our larger towns, are furnished by this immense middle tier or belt, and represent its general appearance. From its lowest to its highest beds it is charged with fossil fish and obscure vegetable impressions; and we find it represented in the Cromarty section by alternating bands of sandstones, stratified clays, and bituminous and nodular limestones, which form altogether a bed three hundred and fifty-five feet in thickness; nor does this bed lack its organisms, animal and vegetable, generically identical with those of Caithness. The apex of the pyramid is formed of red mouldering sandstones and mottled marls, which exhibit their uppermost strata high over the eddies of the Pentland Frith, in the huge precipices of Dunnet-head, and which are partially represented in the Cromarty section by an unfossiliferous sandstone bed of unascer-

tained thickness, but which can be traced for about eighty feet from the upper limestones and stratified clays of the middle member, until lost in overlying beds of sand and shingle.

I am particular, at the risk, I am afraid, of being tedious, in thus describing the Geology of this northern county, and of the Cromarty section, which represents and elucidates it. They illustrate more than the formations of two insulated districts: they represent also a vast period of time in the history of the globe. The pyramid with its three huge bars, its foundations of granitic rock, its base of red conglomerate, its central band of dark-coloured schist, and its lighter tinted apex of sandstone, is inscribed from bottom to top, like an Egyptian obelisk, with a historical record. The upper and lower sections treat of tempests and currents—the middle is "written within and without" with wonderful narratives of animal life; and yet the whole taken together comprises but an earlier portion of that chronicle of existences and events furnished by the Old Red Sandstone. It is, however, with this earlier portion that my acquaintance is most minute.

My first statement regarding it must be much the reverse of the borrowed one with which this chapter begins. *The fossils are remarkably numerous, and in a state of high preservation.* I have a hundred solid proofs by which to establish the truth of the assertion, within less than a yard of me. Half my closet walls are covered with the peculiar fossils of the Lower Old Red Sandstone; and certainly a stranger assemblage of forms have rarely been grouped together;—creatures whose very type is lost, fantastic and uncouth, and

which puzzle the naturalist to assign them even their class;—boat-like animals, furnished with oars and a rudder;—fish plated over, like the tortoise, above and below, with a strong armour of bone, and furnished with but one solitary rudder-like fin; other fish less equivocal in their form, but with the membranes of their fins thickly covered with scales;—creatures bristling over with thorns; others glistening in an enamelled coat, as if beautifully japanned—the tail, in every instance among the less equivocal shapes, formed not equally, as in existing fish, on each side the central vertebral bone, but chiefly on the lower side—the bone sending out its diminished vertebræ to the extreme termination of the fin. All the forms testify of a remote antiquity—of a period whose "fashions have passed away." The figures on a Chinese vase or an Egyptian obelisk are scarce more unlike what now exists in nature, than the fossils of the Lower Old Red Sandstone.

Geology, of all the sciences, addresses itself most powerfully to the imagination, and hence one main cause of the interest which it excites. Ere setting ourselves minutely to examine the peculiarities of these creatures, it were perhaps well that the reader should attempt realizing the *place* of their existence, and relatively the *time*—not of course with regard to dates and eras, for the geologist has none to reckon by, but with respect to formations. They were the denizens of the same portion of the globe which we ourselves inhabit, regarded not as a tract of country, but as a piece of ocean crossed by the same geographical lines of latitude and longitude. Their present place of

sepulture in some localities, had there been no denudation, would have been raised high over the tops of our loftiest hills—at least a hundred feet over the conglomerates which form the summit of Morvheim, and more than a thousand feet over the snow-capped Ben Wyvis. Geology has still greater wonders. I have seen belemnites of the Oolite—comparatively a modern formation—which had been dug out of the sides of the Himalaya mountains, seventeen thousand feet over the level of the sea. But let us strive to carry our minds back, not to the place of sepulture of these creatures, high in the rocks—though that I shall afterwards attempt minutely to describe—but to the place in which they lived, long ere the sauroid fishes of Burdie House had begun to exist, or the corallines of the mountain limestone had spread out their multitudinous arms in a sea gradually shallowing, and out of which the land had already partially emerged.

A continuous ocean spreads over the space now occupied by the British islands: in the tract covered by the green fields and brown moors of our own country, the bottom, for a hundred yards downwards, is composed of the debris of rolled pebbles and coarse sand intermingled, long since consolidated into the lower member of the Old Red Sandstone; the upper surface is composed of banks of sand, mud, and clay; and the sea, swarming with animal life, flows over all. My present object is to describe the inhabitants of that sea.

Of these, the greater part yet discovered have been named by Agassiz, the highest authority as an ich-

thyologist in Europe or the world, and in whom the scarcely more celebrated Cuvier recognised a naturalist in every respect worthy to succeed him. The comparative amount of the labours of these two great men in fossil ichthyology, and the amazing acceleration which has taken place within the last few years in the progress of geological science, are illustrated together, and that very strikingly, by the following interesting fact—a fact derived directly from Agassiz himself, and which must be new to the great bulk of my readers. When Cuvier closed his researches in this department, he had named and described, for the guidance of the geologist, ninety-two distinct species of fossil fish; nor was it then known that the entire geological scale, from the Upper Tertiary to the Grauwacke inclusive, contained more. Agassiz commenced his labours; and in a period of time little exceeding fourteen years, he has raised the number of species from ninety-two to sixteen hundred. And this number, great as it is, is receiving accessions almost every day. In his late visit to Scotland, he found eleven new species, and one new genus, in the collection of Lady Cumming of Altyre, all from the upper beds of that lower member of the Old Red Sandstone represented by the dark-coloured schists and inferior sandstones of Caithness. He found forty-two new species more in a single collection in Ireland, furnished by the Mountain Limestone of Armagh.

Some of my humbler readers may possibly be repelled by his names; they are, like all names in science, unfamiliar in their aspect to mere English readers, just because they are names not for England

alone, but for England and the world. I am assured, however, that they are all composed of very good Greek, and picturesquely descriptive of some peculiarity in the fossils they designate. One of his ichthyolites with a thorn or spine in each fin, bears the name of *Acanthodes*, or thorn-like; another, with a similar mechanism of spines attached to the upper part of the body, and in which the pectoral or hand-fins are involved, has been designated the *Cheiracanthus*, or thorn-hand; a third, covered with curiously-fretted scales, has been named the *Glyptolepis*, or carved-scale; and a fourth, roughened over with berry-like tubercules, that rise from strong osseous plates, is known as the *Coccosteus*, or berry-on-bone. And such has been his principle of nomenclature. The name is a condensed description. But though all his names mean something, they cannot mean a great deal; and as learned words repel unlearned readers, I shall just take the liberty of reminding mine of the humbler class, that there is no legitimate connection between Geology and the dead languages. The existences of the Old Red Sandstone had lived for ages, and had been dead for myriads of ages, ere there was Greek enough in the world to furnish them with names. There is no working man, if he be a person of intelligence and information, however unlearned in the vulgar acceptation of the phrase, who may not derive much pleasure and enlargement of idea from the study of Geology, and acquaint himself as minutely with its truths as if possessed of all the learning of Bentley.

CHAPTER III.

Lamarck's Theory of Progression illustrated—Class of Facts which give Colour to it—The Credulity of *Unbelief*—M. Maillet and his Fish-birds—Gradation not Progress—Geological Argument—The Present incomplete without the Past—Intermediate Links of Creation—Organisms of the Lower Old Red Sandstone—The *Pterichthys*—Its first Discovery—Mr Murchison's Decision regarding it—Confirmed by that of Agassiz—Description—The several Varieties of the Fossil yet discovered—Evidence of Violent Death, in the Attitudes in which they are found—The *Coccosteus* of the Lower Old Red.—Description—Gradations from Crustacea to Fishes—Habits of the *Coccosteus*—Scarcely any conception too Extravagant for Nature to realize.

Mr Lyell's brilliant and popular work, *The Principles of Geology*, must have introduced to the knowledge of most of my readers the strange theories of Lamarck. The ingenious foreigner, on the strength of a few striking facts, which prove that, to a certain extent, the instincts of species may be improved and heightened, and their forms changed from a lower to a higher degree of adaptation to their circumstances, has concluded that there is a natural progress from the inferior orders of being towards the superior; and that the offspring of creatures low in the scale in the present time, may hold a much higher place in it, and

belong to different and nobler species, a few thousand years hence. The descendants of the *ourang-outang*, for instance, may be employed in some future age in writing treatises on Geology, in which they shall have to describe the remains of the *quadrumana* as belonging to an extinct order. Lamarck himself, when bearing home in triumph with him the skeleton of some huge salamander or crocodile of the Lias, might indulge, consistently with his theory, in the pleasing belief that he had possessed himself of the bones of his grandfather—a grandfather removed, of course, to a remote degree of consanguinity, by the intervention of a few hundred thousand *great-greats*. Never yet was there a fancy so wild and extravagant but there have been men bold enough to dignify it with the name of philosophy, and ingenious enough to find reasons for the propriety of the name.

The setting-dog is *taught* to set; he squats down and points at the game; but the habit is an acquired one—a mere trick of education. What, however, is merely acquired habit in the progenitor, is found to pass into instinct in the descendant; the puppy of the setting-dog squats down and sets *untaught*—the educational trick of the parent is mysteriously transmuted into an original principle in the offspring. The adaptation which takes place in the forms and constitution of plants and animals, when placed in circumstances different from their ordinary ones, is equally striking. The woody plant of a warmer climate, when transplanted into a colder, frequently exchanges its ligneous stem for a herbaceous one, as if in anticipation of the killing frosts of winter; and,

dying to the ground at the close of autumn, shoots up again in spring. The dog, transported from a temperate into a frigid region, exchanges his covering of hair for a covering of wool; when brought back again to his former habitat, the wool is displaced by the original hair. And hence, and from similar instances, the derivation of an argument, good so far as it goes, for changes in adaptation to altered circumstances of the organization of plants and animals, and for the improvability of instinct. But it is easy driving a principle too far. The elasticity of a common bow, and the strength of an ordinary arm, are fully adequate to the transmission of an arrow from one point of space to another point a hundred yards removed; but he would be a philosopher worth looking at who would assert that they were equally adequate for the transmission of the same arrow from points removed, not by a hundred yards, but by a hundred miles. And such, but still more glaring, has been the error of Lamarck. He has argued on this principle of improvement and adaptation—which, carry it as far as we rationally may, still leaves the vegetable a vegetable, and the dog a dog—that in the vast course of ages, inferior have risen into superior natures, and lower into higher races; that molluscs and zoophites have passed into fish and reptiles, and fish and reptiles into birds and quadrupeds; that unformed gelatinous bodies, with an organization scarcely traceable, have been metamorphosed into oaks and cedars; and that monkeys and apes have been transformed into human creatures, capable of understanding and admiring the theories of Lamarck. Assuredly there is no lack of

faith among infidels; their "vaulting" credulity o'er-leaps revelation, and "falls on the other side." One of the first geological works I ever read was a philosophical romance, entitled *Teliamed*, by a Mon. Maillet, an ingenious Frenchman of the days of Louis XV. This Maillet was by much too great a philosopher to credit the scriptural account of Noah's flood; and yet he could believe, like Lamarck, that the whole family of birds had existed at one time as fishes, which, on being thrown ashore by the waves, had got feathers by accident; and that men themselves are but the descendants of a tribe of sea-monsters, who, tiring of their proper element, crawled up the beach one sunny morning, and taking a fancy to the land, forgot to return.*

* Few men could describe better than Maillet. His extravagances are as amusing as those of a fairy tale, and quite as extreme. Take the following extract as an instance:—

"Winged or flying fish, stimulated by the desire of prey, or the fear of death, or pushed near the shore by the billows, have fallen among reeds or herbage, whence it was not possible for them to resume their flight to the sea, by means of which they had contracted their first facility of flying. Then their fins, being no longer bathed in the sea-water, were split, and became warped by their dryness. While they found, among the reeds and herbage among which they fell, any aliments to support them, the vessels of their fins being separated, were lengthened and clothed with beards, or, to speak more justly, the membranes which before kept them adherent to each other, were metamorphosed. The beard formed of these warped membranes was lengthened. The skin of these animals was insensibly covered with a down of the same colour with the skin, and this down gradually increased. The little wings they had under their belly, and which, like their wings, helped them to walk in the sea, became feet, and served them to walk on land. There were also other small changes in their figure. The beak and neck of some

"How easy," says this fanciful writer, "is it to conceive the change of a winged fish, flying at times through the water, at times through the air, into a bird flying always through the air!" It is a law of nature, that the chain of being, from the lowest to the highest form of life, should be, in some degree, a continuous chain; that the various classes of existence should shade into one another, so that it often proves a matter of no little difficulty to point out the exact line of demarcation where one class or family ends and another class or family begins. The naturalist passes from the vegetable to the animal tribes, scarcely aware, amid the perplexing forms of intermediate existence, at what point he quits the precincts of the one to enter on those of the other. All the animal families have, in like manner, their connecting links; and it is chiefly out of these that writers such as Lamarck and Maillet construct their system. They confound gradation with progress. Geoffrey Hudson was a very short man, and Goliath of Gath a

were lengthened, and those of others shortened. The conformity, however, of the first figure subsists in the whole, and it will be always easy to know it. Examine all the species of fowls, large and small, even those of the Indies, those which are tufted or not, those whose feathers are reversed, such as we see at Damietta—that is to say, whose plumage runs from the tail to the head—and you will find species of fish quite similar, scaly or without scales. All species of parrots, whose plumages are so different, the rarest and the most singular-marked birds, are, conformable to fact, painted like them with black, brown, grey, yellow, green, red, violet-colour, and those of gold and azure; and all this precisely in the same parts where the plumages of those birds are diversified in so curious a manner."—*Teliamed*, p. 224, ed. 1750.

very tall one, and the gradations of the human stature lie between. But gradation is not progress; and though we find full-grown men of five feet, five feet six inches, six feet, and six feet and a half, the fact gives us no earnest whatever that the race is rising in stature, and that at some future period the average height of the human family will be somewhat between ten and eleven feet. And equally unsolid is the argument that from a principle of gradation in races would deduce a principle of progress in races. The tall man of six feet need entertain quite as little hope of rising into eleven feet as the short man of five; nor has the fish that occasionally flies any better chance of passing into a bird, than the fish that only swims.

Geology abounds with creatures of the intermediate class: there are none of its links more numerous than its connecting links; and hence its interest, as a field of speculation, to the assertors of the transmutation of races. But there is a fatal incompleteness in the evidence, that destroys its character as such. It supplies in abundance those links of generic connection which, as it were, marry together dissimilar races; but it furnishes no genealogical link to show that the existences of one race derive their lineage from the existences of another. The scene shifts as we pass from formation to formation; we are introduced in each to a new *dramatis personæ;* and there exist no such proofs of their being at once different and yet the same, as those produced in the *Winter's Tale* to show that the grown shepherdess of the one scene is identical with the exposed infant of the scene that went before. Nay, the reverse is well-nigh as strik-

ingly the case, as if the grown shepherdess had been introduced into the earlier scenes of the drama, and the child into its concluding scenes.

The argument is a very simple one. Of all the vertebrata, fishes rank lowest, and in geological history appear first. We find their remains in the Upper Ludlow Rocks, in the Lower, Middle, and Upper Old Red Sandstone, in the Mountain Limestone, and in the Coal Measures: we find them also in the Magnesian Limestone; and in the latter formation the first reptiles appear. Fishes seem to have been the master existences of five succeeding formations, ere the age of reptiles began. Now fishes differ very much among themselves: some rank nearly as low as worms, some nearly as high as reptiles; and if fish could have risen into reptiles, and reptiles into mammalia, we would necessarily expect to find lower orders of fish passing into higher, and taking precedence of the higher in their appearance in point of time, just as in the *Winter's Tale* we see the infant preceding the adult. If such be not the case—if fish made their first appearance, not in their least perfect, but in their most perfect state—not in their nearest approximation to the worm, but in their nearest approximation to the reptile—there is no room for progression, and the argument falls. Now it is a geological fact, that it is fish of the higher orders that appear first on the stage, and that they are found to occupy exactly the same level during the vast period represented by five succeeding formations. There is no progression. If fish rose into reptiles, it must have been by sudden transformation—it must

have been as if a man who had stood still for half a life-time should bestir himself all at once, and take seven leagues at a stride. There is no getting rid of miracle in the case—there is no alternative between creation and metamorphosis. The infidel substitutes progression for Deity—Geology robs him of his god.

But no man who enters the geological field in quest of the wonderful, need pass in pursuit of his object from the true to the fictitious. Does the reader remember how, in Milton's sublime figure, the body of Truth is represented as hewn in pieces, and her limbs scattered over distant regions, and how her friends and disciples have to go wandering all over the world in quest of them? There is surely something very wonderful in the fact, that in uniting the links of the chain of creation into an unbroken whole, we have in like manner to seek for them all along the scale of the geologist;—some we discover among the tribes first annihilated—some among the tribes that perished at a later period—some among the existences of the passing time. We find the present incomplete without the past—the recent without the extinct. There are marvellous analogies which pervade the scheme of Providence, and unite, as it were, its lower with its higher parts. The perfection of the works of Deity is a perfection entire in its components, and yet these are not contemporaneous, but successive: it is a perfection which includes the dead as well as the living, and bears relation in its completeness, not to time, but to eternity.

We find the organisms of the Old Red Sandstone supplying an important link, or rather series of links,

in the ichthyological scale, which are wanting in the present creation, and the absence of which evidently occasions a wide gap between the two grand divisions or series of fishes—the bony and the cartilaginous. Of this, however, more anon. Of all the organisms of the system, one of the most extraordinary, and in which Lamarck would have most delighted, is the *Pterichthys*, or winged fish, an ichthyolite which the writer had the pleasure of introducing to the acquaintance of geologists nearly three years ago, but which he first laid open to the light about seven years earlier. Had Lamarck been the discoverer, he would unquestionably have held that he had caught a fish almost in the act of wishing itself into a bird. There are wings which want only feathers, a body which seems to have been as well adapted for passing through the air as the water, and a tail by which to steer. And yet there are none of the fossils of the Old Red Sandstone which less resemble anything that now exists than its *Pterichthys*. I fain wish I could communicate to the reader the feeling with which I contemplated my first-found specimen. It opened with a single blow of the hammer; and there, on a ground of light-coloured limestone, lay the effigy of a creature fashioned apparently out of jet, with a body covered with plates, two powerful-looking arms articulated at the shoulders, a head as entirely lost in the trunk as that of the ray or the sun-fish, and a long angular tail. My first-formed idea regarding it was, that I had discovered a connecting link between the tortoise and the fish—the body much resembles that of a small turtle; and why, I asked, if one formation

Pterichthys oblongus Ag.

Fig. 1

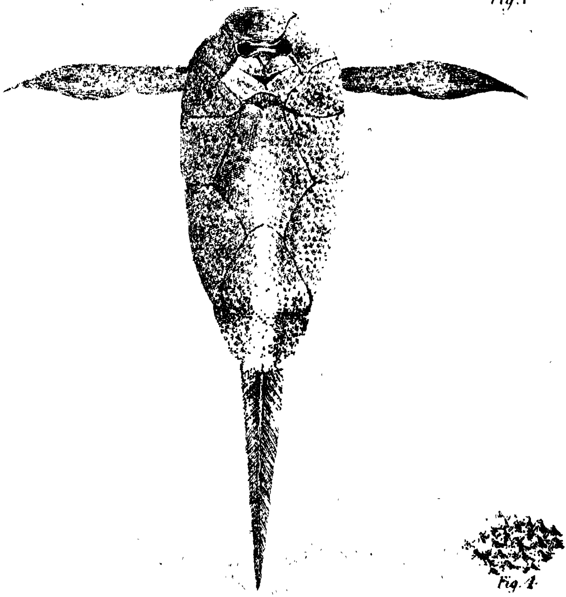


Fig. 4

P. Milleri Ag.

Fig. 2.

gives us sauroid fishes, may not another give us chelonian ones? or if in the Lias we find the body of the lizard mounted on the paddles of the whale, why not find in the Old Red Sandstone the body of the tortoise mounted in a somewhat similar manner? The idea originated in error, but as it was an error which not many naturalists could have corrected at the time, it may be deemed an excusable one, more especially by such of my readers as may have seen well preserved specimens of the creature, or who examine the subjoined prints. (Nos. I. and II.) I submitted some of my specimens to Mr Murchison, at a time when that gentleman was engaged among the fossils of the Silurian System, and employed on his great work, which has so largely served to extend geological knowledge regarding those earlier periods in which animal life first began. He was much interested in the discovery: it furnished the geologist with additional data by which to regulate and construct his calculations, and added a new and very singular link to the chain of existence in its relation to human knowledge. Deferring to Agassiz, as the highest authority, he yet anticipated the decision of that naturalist regarding it in almost every particular. I had inquired, under the influence of my first impression, whether it might not be considered as a sort of intermediate existence between the fish and the chelonian. He stated, in reply, that he could not deem it referrible to any family of reptiles; that if not a fish, it approached more closely to the crustacea than to any other class; and that he had little doubt Agassiz would pronounce it to be an ichthyolite of that ancient

order to which the *Cephalaspis* belongs, and which seems to have formed a connecting link between crustacea and fishes.* The specimens submitted to Mr. Murchison were forwarded to Agassiz. They were much more imperfect than some which I have since disinterred; and to restore the entire animal from them would require powers such as those possessed by Cuvier in the past age, and by the naturalist of Neufchatel in the present. Broken as they were, however, Agassiz at once decided from them that the creature must have been a fish.

I have placed one of the specimens before me. Imagine the figure of a man rudely drawn in black on a grey ground, the head cut off by the shoulders, the

* The aborigines of South America deemed it wonderful that the Europeans who first visited them should, without previous concert, agree in reading after the same manner the same scrap of manuscript, and in deriving the same piece of information from it. The writer experienced on this occasion a somewhat similar feeling. His specimens seemed written in a character cramp enough to suggest those doubts regarding original meaning which lead to various readings, but the geologist and the naturalist agreed in perusing them after exactly the same fashion—the one in London, the other in Neufchatel. Such instances give confidence in the findings of science. The decision of Mr. Murchison I subjoin in his own words—his numbers refer to various specimens of *Pterichthys:* "As to your fossils 1, 2, 3, we know nothing of them here (London), except that they remind me of the occipital fragments of some of the Caithness fishes. I do not conceive they can be referrible to any reptile; for, if not fishes, they more closely approach to crustaceans than to any other class. I conceive, however, that Agassiz will pronounce them to be fishes, which, together with the curious genus *Cephalaspis* of the Old Red Sandstone, form the connecting links between crustaceans and fishes. Your specimens remind one in several respects of the *Cephalaspis.*"

arms spread at full, as in the attitude of swimming, the body rather long than otherwise, and narrowing from the chest downwards, one of the legs cut away at the hip joint, and the other, as if to preserve the balance, placed directly under the centre of the figure, which it seems to support. Such, at a first glance, is the appearance of the fossil. The body was of very considerable depth, perhaps little less deep proportionally from back to breast than the body of the tortoise; the under part was flat, the upper rose towards the centre into a roof-like ridge, and both under and upper were covered with a strong armour of bony plates, which, resembling more the plates of the tortoise than those of the crustacean, received their accessions of growth at the edges or sutures. The plates on the under side are divided by two lines of suture, which run, the one longitudinally through the centre of the body, the other transversely, also through the centre of it; and they would cut one another at right angles, were there not a lozenge-shaped plate inserted at the point where they would otherwise meet. There are thus five plates on the lower or belly part of the animal. They are all thickly tuberculated outside with wart-like prominences (see Plate I., fig. 4); the inner present appearances indicative of a bony structure. The plates on the upper side are more numerous and more difficult to describe, just as it would be difficult to describe the forms of the various stones which compose the ribbed and pointed roof of a Gothic cathedral, the arched ridge or hump of the back requiring, in a somewhat similar way, a peculiar form and arrangement of plates. The apex of the ridge is covered by a strong

hexagonal plate, fitted upon it like a cap or helmet, and which nearly corresponds in place to the flat central plate of the under side. There runs around it a border of variously-formed plates, that diminish in size and increase in number towards the head, and which are separated like the pieces of a dissected map, by deep sutures. They all present the tuberculated surface. The eyes are placed in front, on a prominence much lower than the roof-like ridge of the back; the mouth seems to have opened, as in many fishes, in the edge of the creature's snout, where a line running along the back would bisect a line running along the belly, but this part is less perfectly shown by my specimens than any other. The two arms or paddles are placed so far forward as to give the body a disproportionate and decapitated appearance. From the shoulder to the elbow, if I may employ the terms, there is a swelling muscular appearance, as in the human arm; the part below is flattened so as to resemble the blade of an oar, and it terminates in a strong sharp point. The tail—the one leg on which, as exhibited in one of my specimens, the creature seems to stand—is of considerable length, more than equal to a third of the entire figure, and of an angular form, the base representing the part attached to the body, and the apex its termination. It was covered with small tuberculated rhomboidal plates, like scales (see Plate I., fig. 3); and where the internal structure is shown, there are appearances of a vertebrated bone, with rib-like processes standing out at a sharp angle. The ichthyolite, in my larger specimens, does not much exceed seven inches in length, and I despatched one

Pterichthys
oblongus Ag.

Fig 2.

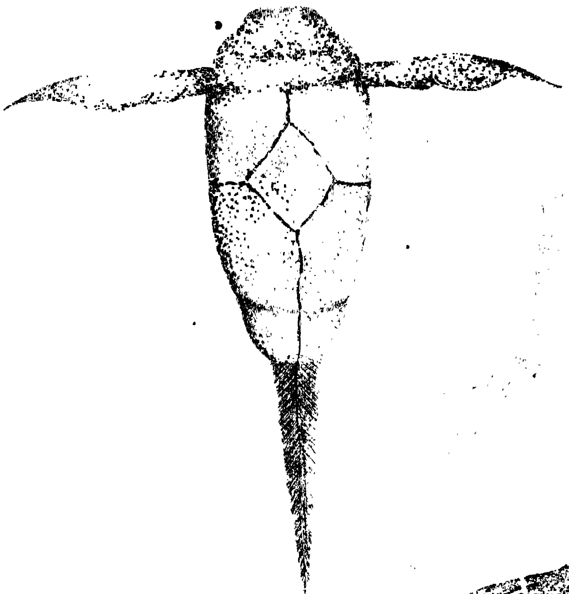


Fig 3

P. Milleri Ag

Fig. 1.

to Agassiz rather more than two years ago, whose extreme length did not exceed an inch. Such is a brief, and, I am afraid, imperfect sketch of a creature whose very type seems no longer to exist. But for the purposes of the geologist, the descriptions of the graver far exceed those of the pen, and the accompanying prints will serve to supply all that may be found wanting in the text. Fig. 1, in Plate I., and fig. 2 in Plate II., are both restorations—the first of the upper, and the second of the under, part of the creature. It may, however, encourage the confidence of the naturalist, who for the first time looks upon forms so strange, to be informed that Plate I., with its two figures, was submitted to Agassiz during his recent brief stay in Edinburgh, and that he as readily recognised in it the species of the two varieties which it exhibits, as he had previously recognised the species of the originals in the limestone.

Agassiz, in the course of his late visit to Scotland, found six species of the *Pterichthys**—three of these, and the wings of a fourth, in the collection of the writer. The differences by which they are distinguished may be marked by even an unpractised eye, especially in the form of the bodies and wings. Some are of a fuller, some of a more elongated, form; in some the body resembles a heraldic shield, of nearly the ordinary shape and proportions; in others the

* Agassiz now reckons ten distinct species of *Pterichthys*—*P. arenatus*, *P. cancriformis*, *P. cornutus*, *P. major*, *P. Milleri*, *P. latus*, *P. oblongus*, *P. productus*, *P. testudinarius*, and *P. hydrophilus;* of these, nine species belong to the Lower, and one—the *Pterichthys hydrophilus*—to the Upper Old Red Sandstone.

shield stretches into a form not very unlike that of a Norway skiff, from the midships forward. In some of the varieties, too, the wings are long and comparatively slender, in others shorter and of greater breadth; in some there is an inflection resembling the bend of an elbow, in others there is a continuous swelling from the termination to the shoulder, where a sudden narrowing takes place immediately over the articulation. I had inferred somewhat too hurriedly, though perhaps naturally enough, that these wings or arms, with their strong sharp points and oar-like blades, had been at once paddles and spears—instruments of motion and weapons of defence; and hence the mistake of connecting the creature with the Chelonia. I am informed by Agassiz, however, that they were weapons of defence only, which, like the occipital spines of the river bull-head, were erected in moments of danger or alarm, and at other times lay close by the creature's side; and that the sole instrument of motion was the tail, which, when covered by its coat of scales, was proportionally of a somewhat larger size than the tail shown in the print, which, as in the specimens from which it was taken, exhibits but the obscure and uncertain lineaments of the skeleton. The river bull-head, when attacked by an enemy, or immediately as it feels the hook in its jaws, erects its two spines at nearly right angles with the plates of the head, as if to render itself as difficult of being swallowed as possible. The attitude is one of danger and alarm; and it is a curious fact, to which I shall afterwards have occasion to advert, that in this attitude nine-tenths of the *Pterichthyes* of the Lower Old Red Sandstone are

PLATE

Coccosteus Cuspidatus Ag. Fig. 1.

Fig

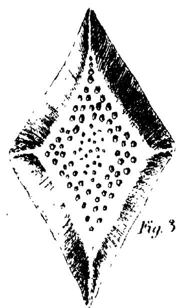


Fig. 3

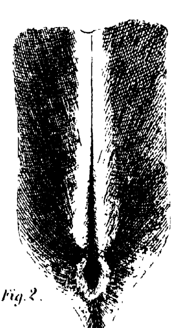


Fig. 2.

to be found. We read in the stone a singularly-preserved story of the strong instinctive love of life, and of the mingled fear and anger implanted for its preservation—"The champions in distorted postures threat." It presents us, too, with a wonderful record of violent death falling at once, not on a few individuals, but on whole tribes.

Next to the *Pterichthys* of the Lower Old Red I shall place its cotemporary the *Coccosteus* of Agassiz, a fish which, in some respects, must have somewhat resembled it. Both were covered with an armour of thickly tuberculated bony plates, and both furnished with a vertebrated tail. The plates of the one, when found lying detached in the rock, can scarcely be distinguished from those of the other: there are the same marks as in the plates of the tortoise, of accessions of growth at the edges—the same porous bony structure within, the same kind of tubercules without. The forms of the creatures themselves, however, were essentially different. I have compared the figure of the *Pterichthys*, as shown in some of my better specimens, to that of a man with the head cut off by the shoulders, one of the legs also wanting, and the arms spread to the full. The figure of the *Coccosteus* I would compare to a boy's kite. (See Plate III., fig. 1.) There is a rounded head, a triangular body, a long tail attached to the apex of the triangle, and arms thin and rounded where they attach to the body, and spreading out towards their termination like the ancient one-sided shovel which we see sculptured on old tombstones, or the rudder of an ancient galley. The manner in which the plates are arranged on the

head is peculiarly beautiful; but I am afraid I cannot adequately describe them. A ring of plates, like the ring-stones of an arch, runs along what may be called the hoop of the kite; the form of the key-stone-plate is perfect; the shapes of the others are elegantly varied, as if for ornament; and what would be otherwise the opening of the arch, is filled up with one large plate, of an outline singularly elegant. A single plate, still larger than any of the others, covers the greater part of the creature's triangular body, to the shape of which it nearly conforms. It rises saddle-wise towards the centre: on the ridge there is a longitudinal groove ending in a perforation, a little over the apex (Plate III., fig. 2); two small lateral plates on either side fill up the base of the angle; and the long vertebrated tail terminates the figure.

Does the reader possess a copy of Lyell's lately published elementary work, edition 1838? If so, let him first turn up the description of the upper Silurian rocks, from Murchison, which occurs in page 459, and mark the form of the trilobite *Asaphus caudatus*, a fossil of the Wenlock formation. (See *Sil. Sys.*, Plate VII.) The upper part, or head, forms a crescent; the body rises out of the concave with a sweep somewhat resembling that of a Gothic arch; the outline of the whole approximates to that of an egg, the smaller end terminating in a sharp point. Let him remark, further, that this creature was a *crustaceous* animal, of the crab or lobster family, and then turn up the brief description of the Old Red Sandstone in the same volume, page 454, and mark the form

of the *Cephalaspis*, or buckler-head—a *fish* of a formation over that in which the remains of the trilobite most abound. He will find that the fish and crustacean are wonderfully alike. The fish is more elongated, but both possess the crescent-shaped head, and both the angular and apparently jointed body.* They illustrate admirably how two distinct orders may meet. They exhibit the points, if I may so speak, at which the plated fish is linked to the shelled crustacean. Now, the *Coccosteus* is a stage further on; it is more unequivocally a fish. It is a *Cephalaspis* with an articulated tail attached to the angular body, and the horns of the crescent-shaped head cut off.

Some of the specimens which exhibit this creature are exceedingly curious. In one, a coprolite still rests in the abdomen; and a common botanist's microscope shows it thickly speckled over with minute scales, the indigestible exuviæ of fish on which the animal preyed. In the abdomen of another we find a few minute pebbles—just as pebbles are occasionally found in the stomach of the cod—which had been swallowed by the creature attached to its food. Is there nothing wonderful in the fact that men should be learning at

* Really jointed in the case of the trilobite; only apparently so in that of the *Cephalaspis*. The body of the trilobite, like that of the lobster, was barred by transverse oblong overlapping plates, and between every two plates there was a joint; the body of the *Cephalaspis*, in like manner, was barred by transverse oblong overlapping scales, between which there existed no such joints. It is interesting to observe how nature, in thus bringing two such different classes as fishes and crustacea together, gives to the higher animal a sort of pictorial resemblance to the lower, in parts where the construction could not be identical without interfering with the grand distinctions of the classes.

this time of day how the fishes of the Old Red Sandstone lived, and that there were some of them rapacious enough not to be over nice in their eating?

The under part of the creature is still very imperfectly known: it had its central lozenge-shaped plate, like that on the under side of the *Pterichthys*, but of greater elegance (see Plate III., fig. 3), round which the other plates were ranged. "What an appropriate ornament, if set in gold!" said Dr. Buckland, on seeing a very beautiful specimen of this central lozenge in the interesting collection of Professor Traill of Edinburgh—"What an appropriate ornament for a lady geologist!" There are two marked peculiarities in the jaws of the *Coccosteus*, as shown in most of the specimens illustrative of the lower part of the creature which I have yet seen. The teeth, instead of being fixed in sockets, like those of quadrupeds and reptiles, or merely placed on the bone, like those of fish of the common varieties, seem to have been cut out of the solid, like the teeth of a saw or the teeth in the mandibles of the beetle, or in the nippers of the lobster (Plate III., fig. 4); and there appears to have been something strangely anomalous in the position of the jaws—something too anomalous, perhaps, to be regarded as proven by the evidence of the specimens yet found, but which may be mentioned with the view of directing attention to it. "Do not be deterred," said Agassiz, in the course of one of the interviews in which he obligingly indulged the writer of these chapters, who had mentioned to him that one of his opinions, just confirmed by the naturalist, had seemed so extraordinary that he had been almost afraid to

communicate it—"Do not be deterred, if you have examined minutely, by any dread of being deemed extravagant. The possibilities of existence run so deeply into the extravagant, that there is scarcely any conception too extraordinary for nature to realize." In all the more complete specimens which I have yet seen, *the position of the jaws is vertical, not horizontal;* and yet the creature, as shown by the tail, belonged unquestionably to the vertebrata. Now, though the mouths of the crustaceous animals, such as the crab and lobster, open vertically, and a similar arrangement obtains among the insect tribes, it has been remarked by naturalists as an invariable condition of that higher order of animals distinguished by vertebrated columns, that their mouths open horizontally. What I would remark as very extraordinary in the *Coccosteus*—not, however, in the way of directly asserting the fact, but merely by way of soliciting inquiry regarding it—is, that it seems to unite to a vertebral column a vertical mouth, thus forming a connecting link between two orders of existences, by conjoining what is at once their most characteristic and most dissimilar traits.*

* These statements regarding the character of the teeth and the position of the jaws of the *Coccosteus* have been challenged by very high authorities. I retain them, however, in this edition in their original form, as first made nearly six years ago. In at least two of my specimens of *Coccosteus* the teeth and jaw form unequivocally but one bone, a result it is not improbable of some after anchylosing process, but which still solicits inquiry as not yet definitely accounted for. The matter of fact in the case is certainly one which should be determined not analogically, but on its own proper evidence, as furnished by good specimens. As for the remark regarding the probable position of the creature's

I am acquainted with four species of *Coccosteus*—*C. latus*, *C. cuspidatus*, *C. oblongus*, and a variety not yet named,* and many more species may yet be discovered. Of all the existences of the formation, this curious fish seems to have been one of the most abundant. In a few square yards of rock I have laid open portions of the remains of a dozen different individuals belonging to two of the four species, the *C. latus* and *C. cuspidatus*, in the course of a single evening. None of the other kinds have yet been found at Cromarty.† These two differed from each other in the proportions which their general bulk bore to their length—slightly, too, in the arrangement of their occipital plates. The *Coccosteus latus*, as the name implies, must have been by much a massier fish than the other; and we find the arch-like form of the plates which covered its head more complete: the plate representing the key-stone rests on the saddle-shaped plate in the centre, and the plates representing the spring-stones of the arch exhibit a broader base. The accompanying print (Plate III.) represents

jaws, it was ventured on at first, as the reader may perceive, with much hesitation, and must now be regarded as more doubtful than ever. Its repetition here, however, will, I trust, be regarded as simply indicative of a wish on the part of the writer that the question be kept open just a little longer, and that further examination be made. There is certainly something very peculiar about the mouth of the *Coccosteus* not yet understood, and singularly-formed plates, connected with it, which have not been introduced into my restoration, and the use of which in the economy of the animal seem wholly unknown.

* Now termed *Coccosteus decipiens;* a fifth species has been named, *C. maximus.*

† The *Coccosteus decipiens* also occurs at Cromarty.

the *Coccosteus cuspidatus*. The average length of the creature, including the tail, as shown in most of the Cromarty specimens, somewhat exceeded a foot. A few detached plates from Orkney, in the collection of Dr. Traill, must have belonged to an individual of fully twice that length.

CHAPTER IV.

The Elfin-fish of Gawin Douglas—The fish of the Old Red Sandstone scarcely less curious—Place which they occupied indicated in the present Creation by a mere Gap—Fish divided into two great Series—the Osseous and Cartilaginous—Their distinctive Peculiarities—Geological Illustration of Dr. Johnson's shrewd Objection to the Theory of Soame Jenyns—Proofs of the intermediate Character of the Ichthyolites of the Old Red Sandstone—Appearances which first led the Writer to deem it intermediate—Confirmation by Agassiz—The *Osteolepis*—Order to which this Ichthyolite belonged—Description—*Dipterus*—*Diplopterus*—*Cheirolepis*—*Glyptolepis*.

HAS the reader ever heard of the "griesly fisch" and the "laithlie flood," described by the minstrel Bishop of Dunkeld, "who gave rude Scotland Virgil's page?" Both fish and flood are the extravagances of a poet's dream. The flood came rolling through a wilderness of bogs and quagmires, under banks "dark as rocks the whilk the sey upcast." A skeleton forest stretched around, doddered and leafless; and through the "unblomit" and "barrant" trees

"The quhissling wind blew mony bitter blast;"

the whitened branches "clashed and clattered;" the "vile water rinnand o'erheid," and "routing as thonder," made "hideous trubil;" and to augment the

uproar, the "griesly fisch," like the fish of Eastern story, raised their heads amid the foam, and shrieked and yelled as they passed. "The grim monsters fordeafit the heiring with their schouts;"—they were both fish and elves, and strangely noisy in the latter capacity; and the longer the poet listened, the more frightened he became. The description concludes, like a terrific dream, with his wanderings through the labyrinths of the dead forest, where all was dry and sapless above, and mud and marsh below, and with his exclamations of grief and terror at finding himself hoplessly lost in a scene of prodigies and evil spirits. And such was one of the wilder fancies in which a youthful Scottish poet of the days of Flodden indulged, ere taste had arisen to restrain and regulate invention.

Shall I venture to say, that the ichthyolites of the Old Red Sandstone have sometimes reminded me of the "fisch of the laithlie flood?" They were hardly less curious. We find them surrounded, like these, by a wilderness of dead vegetation and of rocks upcast from the sea; and there are the footprints of storm and tempest around and under them. True, they must have been less noisy. Like the "griesly fisch," however, they exhibit a strange union of opposite natures. One of their families—that of the *Cephalaspis*—seems almost to constitute a connecting link, says Agassiz, between fishes and crustaceans. They had also their families of sauroid or reptile fishes—and their still more numerous families that unite the cartilaginous fishes to the osseous. And to these last the explorer of the Lower Old Red Sandstone

finds himself mainly restricted. The links of the system are all connecting links, separated by untold ages from that which they connect—so that in searching for their representatives amid the existences of the present time, we find but the gaps which they should have occupied. And it is essentially necessary, from this circumstance, in acquainting one's self with their peculiarities, to examine, if I may so express myself, the sides of these gaps—the existing links at both ends to which the broken links should have pieced—in short, all those more striking peculiarities of the existing disparted families which we find united in the intermediate families that no longer exist. Without some such preparation, the inquirer would inevitably share the fate of the poetical dreamer of Dunkeld, by losing his way in a labyrinth. In passing, therefore, with this object from the extinct to the recent, I venture to solicit, for a few paragraphs, the attention of the reader.

Fishes, the fourth great class in point of rank in the animal kingdom, and, in extent of territory, decidedly the first, are divided, as they exist in the present creation, into two distinct series—the osseous and the cartilaginous. The osseous embraces that vast assemblage which naturalists describe as "fishes properly so called," and whose skeletons, like those of mammalia, birds, and reptiles, are composed chiefly of a calcareous earth, pervading an organic base. Hence the durability of their remains. In the cartilaginous series, on the contrary, the skeleton contains scarce any of this earth: it is a frame-work of indurated animal matter, elastic, semi-transparent, yield-

ing easily to the knife, and, like all mere animal substances, inevitably subject to decay. I have seen the huge cartilaginous skeleton of a shark lost in a mass of putrefaction in less than a fortnight. I have found the minutest bones of the osseous ichthyolites of the Lias entire after the lapse of unnumbered centuries.

The two series do not seem to precede or follow one another in any such natural sequence as that in which the great classes of the animal kingdom are arranged. The mammifer takes precedence of the bird, the bird of the reptile, the reptile of the fish; there is progression in the scale—the arrangement of the classes is consecutive, not parallel. But in this great division there is no such progression; the osseous fish takes no precedence of the cartilaginous fish, or the cartilaginous, as a series, of the osseous. The arrangement is parallel, not consecutive; but the parallelism, if I may so express myself, seems to be that of a longer with a shorter line;—the cartilaginous fishes, though much less numerous in their orders and families than the other, stretch farther along the scale in opposite directions, at once rising higher and sinking lower than the osseous fishes. The cartilaginous order of the sturgeons, a roe-depositing tribe, devoid alike of affection for their young, or of those attachments which give the wild beasts of the forest partners in their dens, may be regarded as fully abreast of by much the greater part of the osseous fishes in both their instincts and their organization. The family of the sharks, on the other hand, and some of the rays, rise higher, as if to connect the class of fish with the class

immediately above it—that of reptiles. Many of them are viviparous, like the mammalia—attached, it is said, to their young, and fully equal even to birds in the strength of their connubial attachments. The male, in some instances, has been known to pine away and die when deprived of his female companion.* But then, on the other hand, the cartilaginous fishes, in some of their tribes, sink as low beneath the osseous, as they rise above them in others. The suckers, for instance, a cartilaginous family, are the most imperfect of all vertebrated animals; some of them want even the sense of sight; they seem mere worms furnished with fins and gills, and were so classed by Linnæus; but though now ascertained to be in reality fishes, they must be regarded as the lowest link in the scale—as connecting the class with the class *Vermes*, just as the superior cartilaginous fishes may be regarded as connecting it with the class *Reptilia*.

Between the osseous and the cartilaginous fishes

* Some of the osseous fishes are also viviparous—the "viviparous blenny," for instance. The evidence from which the supposed affection of the higher fishes for their offspring has been inferred, is, I am afraid, of a somewhat equivocal character. The love of the sow for her litter hovers at times between that of the parent and that of the epicure; nor have we proof enough, in the present state of ichthyological knowledge, to conclude to which side the parental love of the fish inclines. The connubial affections of some of the higher families seem better established. Of a pair of gigantic rays (*Cephaloptera giorna*) taken in the Mediterranean, and described by Risso, the female was captured by some fishermen; and the male continued constantly about the boat, as if bewailing the fate of his companion, and was then found floating dead.—See Wilson's article ICHTHYOLOGY, *Encyc. Brit.*, seventh edition.

there exist some very striking dissimilarities. The skull of the osseous fish is divided into a greater number of distinct bones, and possesses more movable parts, than the skulls of mammiferous animals; the skull of the cartilaginous fish, on the contrary, consists of but a single piece, without joint or suture. There is another marked distinction. The bony fish, if it approaches in form to that general type which we recognise amid all the varieties of the class as proper to fishes, and to which, in all their families, nature is continually inclining, will be found to have a tail branching out, as in the perch and herring, from the bone in which the vertebral column terminates; whereas the cartilaginous fish, if it also approach the general type, will be found to have a tail formed, as in the sturgeon and dog-fish, on both sides of the lower portion of the spine, but developed much more largely on the under than on the upper side. In some instances it is wanting on the upper side altogether. It may be as impossible to assign reasons for such relations as for those which exist between the digestive organs and the hoofs of the ruminant animals; but it is of importance that they should be noted.* It may

* Dr. Buckland, in his *Bridgewater Treatise*, assigns satisfactory reasons for this construction of tail in sharks and sturgeons. Of the fishes of these two orders, he states, "the former perform the office of scavengers, to clear the water of impurities, and have no teeth, but feed, by means of a soft leather-like mouth, capable of protrusion and contraction, on putrid vegetables and animal substances at the bottom; and hence they have constantly to keep their bodies in an inclined position. The sharks employ their tail in another peculiar manner—to turn their body, in order to bring their mouth, which is placed downwards beneath the head, into contact with their prey. We find an important

be remarked, further, that the great bulk of fishes whose skeletons consist of cartilage, have yet an ability of secreting the calcareous earth which composes bone, and that they are furnished with bony coverings, either partial or entire. Their bones lie outside. The thorn-back derives its name from the multitudinous hooks and spikes of bone that bristle over its body; the head, back, and operculum of the sturgeon are covered with bony plates; the thorns and prickles of the shark are composed of the same material. The frame-work within is a frame-work of mere animal matter; but it was no lack of the osseous ingredient that led to the arrangement—an arrangement which we can alone refer to the will of that all-potent Creator, who can transpose his materials at pleasure, without interfering with the perfection of his work. It is a curious enough circumstance, that some of the osseous fishes, as if entirely to reverse the condition of the cartilaginous ones, are partially covered with plates of cartilage. They are bone within, and cartilage without, just as others are bone without, and cartilage within.

But how apply all this to the Geology of the Old Red Sandstone? Very directly. The ichthyolites of this ancient formation hold, as has been said, an intermediate place, unoccupied among present existences, between the two series, and in some respects resemble the osseous, and in some the cartilaginous tribes. The fact reminds one of Dr. Johnson's shrewd

provision in every animal, to give a position of ease and activity to the head during the operation of feeding."—*Bridgewater Treatise*, p. 279, vol. i., first edit.

objection to the theory embraced by Soame Jenyns in his *Free Inquiry*, and which was the theory also of Pope and Bolingbroke. The metaphysician held, with the poet and his friend, that there exists a vast and finely-graduated chain of being from Infinity to nonentity—from God to nothing; and that to strike out a single link would be to mar the perfection of the whole.* The moralist demonstrated, on the contrary, that this chain, in the very nature of things, must be incomplete at both ends—that between that which does, and that which does not exist, there must be an infinite difference—that the chain, therefore, cannot lay hold on *nothing*. He showed, further, that between the greatest of finite existences and the adorable Infinite there must exist another illimitable void—that the boundless and the bounded are as widely separated in their natures and qualities as the existent and the non-existent—that the chain, in short, cannot lay hold on Deity. He asserted,

* "See, through this air, this ocean, and this earth,
All matter quick, and bursting into birth;
Above, how high progressive life may go!
Around, how wide! how deep extend below!
Vast chain of being! which from God began—
Nature's ethereal, human angel, man,
Beast, bird, fish, insect—what no eye can see,
No glass can reach; from Infinite to thee—
From thee to nothing. On superior powers
Were we to press, inferior might on ours;
Or in the full creation leave a void,
Where, one step broken, the great scale's destroyed:
From Nature's chain whatever link you strike,
Tenth, or ten thousandth, breaks the chain alike."
Essay on Man.

however, that not only is it thus incomplete at both ends, but that we must regard it as well-nigh as incomplete in many of its intermediate links as at its terminal ones; that it is already a broken chain, seeing that between its various classes of existence myriads of intermediate existences might be introduced, by graduating more minutely what must necessarily be capable of infinite gradation; and that, to base an infidel theory on the supposed completeness of what is demonstrably incomplete, and on the impossibility of a gap existing in what is already filled with gaps, is just to base one absurdity on another.* Now, we

* The following are the well-stated reasonings of Dr. Johnson, a writer who never did injustice to an argument for want of words to express it in:—

"The scale of existence from Infinity to nothing cannot possibly have being. The highest being not infinite must be at an infinite distance from Infinity. Cheyne, who, with the desire inherent in mathematicians to reduce everything to mathematical images, considers all existence as a *cone*, allows that the basis is at an infinite distance from the body, and in this distance between finite and infinite there will be room for ever for an infinite series of indefinable existence.

"Between the lowest positive existence and nothing, whenever we suppose positive existence to cease, is another chasm infinitely deep, where there is room again for endless orders of subordinate nature, continued for ever and ever, and yet infinitely superior to non-existence.

"To these meditations humanity is unequal. But yet we may ask, not of our Maker, but of each other, since on the one side creation, whenever it stops, must stop infinitely below infinity, and on the other infinitely above nothing, what necessity there is that it should proceed so far either way—that being so high or so low should ever have existed. We may ask, but I believe no created wisdom can give an adequate answer.

"Nor is this all. In the scale, wherever it begins or ends,

find the Geology of what may be termed the second age of vertebrated existence (for the Lower Old Red Sandstone was such) coming curiously in to confirm the reasonings of Johnson. It shows us the greater part of the fish of an entire creation thus insinuated between two of the links of our own.

It is now several years since I was first led to suspect that the condition of the ichthyolites of the Old Red Sandstone was intermediate. I have alluded to the comparative indestructibility of the osseous skeleton, and the extreme liability to decay characteristic of the cartilaginous one. Of a skeleton in part osseous and in part cartilaginous, we must, of course, expect, when it occurs in a fossil state, to find the indestructible portions only. And when, in every instance, we find the fossil skeletons of a formation complete in some of their parts, and incomplete in others—the entire portions invariably agreeing, and the wanting portions invariably agreeing also—it seems but natural to conclude that an original difference must have obtained, and that the existing parts, which we can at once recognise as bone, must have been united to parts now wanting, which were composed of cartilage. The naturalist never doubts

are infinite vacuities. At whatever distance we suppose the next order of beings to be above man, there is room for an intermediate order of beings between them; and if for one order, then for infinite orders, since everything that admits of more or less, and consequently all the parts of that which admits them, may be infinitely divided; so that, as far as we can judge, there may be room in the vacuity between any two steps of the scale, or between any two points of the cone of being, for infinite exertion of infinite power."—*Review of* " *A Free Inquiry.*"

that the shark's teeth, which he finds detached on the shore, or buried in some ancient formation, were united originally to cartilaginous jaws. Now, in breaking open all the ichthyolites of the Lower Old Red Sandstone, with the exception of those of the two families already described, we find that some of the parts are invariably wanting, however excellent the state of preservation maintained by the rest. I have seen every scale preserved and in its place—one set of both the larger and smaller bones occupying their original position—jaws thickly set with teeth still undetached from the head—the massy bones of the skull still unseparated—the larger shoulder-bone, on which the operculum rests, lying in its proper bed—the operculum itself entire—and all the external rays which support the fins, though frequently fine as hairs, spreading out distinct as the fibres in the wing of the dragon-fly, or the woody nerves in an oak leaf. In no case, however, have I succeeded in finding a single joint of the vertebral column, or the trace of a single internal ray. No part of the internal skeleton survives, nor does its disappearance seem to have had any connection with the greater mass of putrescent matter which must have surrounded it, seeing that the external rays of the fins show quite as entire when turned over upon the body, as sometimes occurs, as when spread out from it in profile. Besides, in the ichthyolites of the chalk, no parts of the skeleton are better preserved than the internal parts—the vertebral joints, and the internal rays. The reader must have observed, in the cases of a museum of Natural History, preparations of fish of two several kinds—

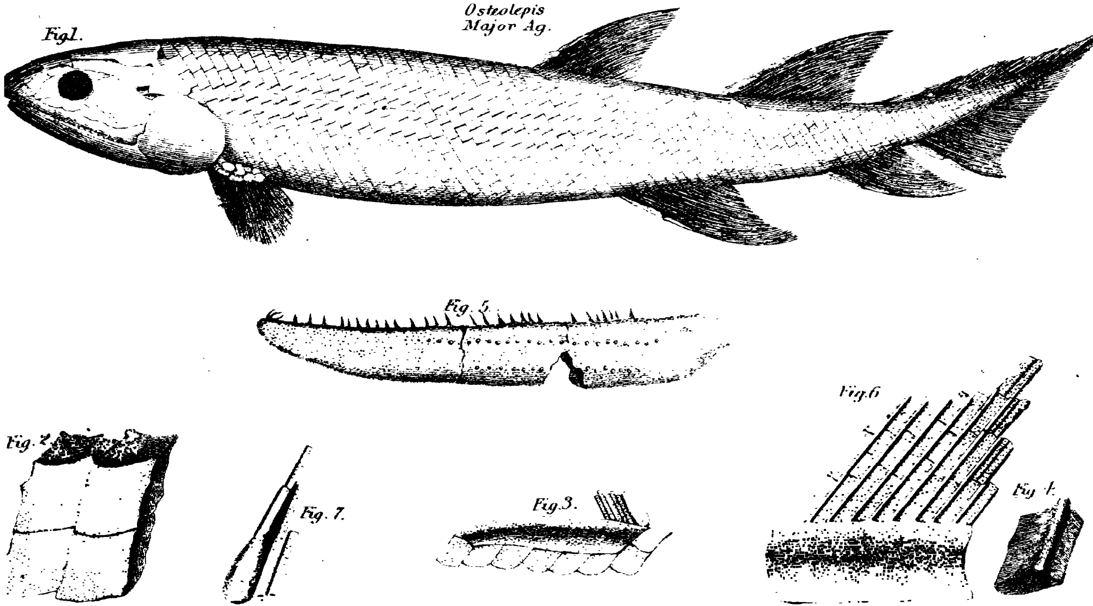
preparations of the skeleton, in which only the osseous parts are exhibited, and preparations of the external form, in which the whole body is shown in profile, with the fins spread to the full, and at least half the bones of the head covered by the skin, but in which the vertebral column and internal rays are wanting. Now, in the fossils of the chalk, with those of the other later formations, down to the New Red Sandstone, we find that the skeleton style of preparation obtains; whereas in at least three-fourths of the ichthyolites of the Lower Old Red, we find only what we may term the external style. I had marked, besides, another circumstance in the ichthyolites, which seemed, like a nice point of circumstantial evidence, to give testimony in the same line. The tails of all the ichthyolites, whose vertebral columns and internal rays are wanting, are unequally lobed, like those of the dog-fish and sturgeon (both cartilaginous fishes), and the body runs on to nearly the termination of the surrounding rays. The one-sided condition of tail exists, says Cuvier, in no recent osseous fish known to naturalists except in the bony pike—a sauroid fish of the warmer rivers of America. With deference, however, to so high an authority, it is questionable whether the tail of the bony pike should not rather be described as a tail set on somewhat awry, than as a one-sided tail.

All these peculiarities I could but note as they turned up before me, and express, in pointing them out to a few friends, a sort of vague, because hopeless, desire that good fortune might throw me in the way of the one man of all the world best qualified to

explain the principle on which they occurred, and to decide whether fishes may be at once bony and cartilaginous. But that meeting was a contingency rather to be wished than hoped for—a circumstance within the bounds of the possible, but beyond those of the probable. Could the working man of the north of Scotland have so much as dreamed that he was yet to enjoy an opportunity of comparing his observations with those of the naturalist of Neufchatel, and of having his inferences tested and confirmed?

The opportunity did occur. The working man did meet with Agassiz; and many a query had he to put to him; and never, surely, was inquirer more courteously entreated, or his doubts more satisfactorily resolved. The reply to almost my first question solved the enigma of nearly ten years' standing. And finely characteristic was that reply of the frankness and candour of a great mind, that can afford to make it no secret, that in its onward advances on knowledge it may know to-day what it did not know yesterday, and that it is content to "gain by degrees upon the darkness." "Had you asked me the question a fortnight ago," said Agassiz, "I could not have replied to it. Since then, however, I have examined an ichthyolite of the Old Red Sandstone in which the vertebral joints are fortunately impressed on the stone, though the joints themselves have disappeared, and which, exactly resembling the vertebræ of the shark, must have been cartilaginous." In a subsequent conversation the writer was gratified by finding most of his other facts and inferences authenticated and confirmed by those of the naturalist. I shall attempt

PLATE IV.



introducing to the reader the peculiarities, general and specific, of the ichthyolites to which these facts and observations mainly referred, by describing such of the families as are most abundant in the formation, and the points in which they either resemble or differ from the existing fish of our seas.

Of these ancient families, the *Osteolepis*, or bony-scale (see Plate IV., fig. 1), may be regarded as illustrative of the general type. It was one of the first discovered of the Caithness fishes, and received its name, in the days of Cuvier, from the osseous character of its scales, ere it was ascertained that it had numerous cotemporaries, and that to all and each of these the same description applied. The scales of the fishes of the Lower Old Red Sandstone, like the plates and detached prickles of the purely cartilaginous fishes, were composed of a bony, not of a horny substance, and were all coated externally with enamel. The circumstance is one of interest.

Agassiz, in his system of classification, has divided fishes into four orders, according to the form of their scales; and his principle of division, though apparently arbitrary and trivial, is yet found to separate the class into great natural families, distinguished from one another by other and very striking peculiarities. One kind of scale, for instance, the placoid or broad-plated scale, is found to characterize all the cartilaginous fishes of Cuvier except the sturgeon;—it is the characteristic of an otherwise well-marked series, whose families are furnished with skeletons composed of mere animal matter, and whose gills open to the water by spiracles. The fish of another order are covered

by ctenoid or comb-shaped scales, the posterior margin of each scale being toothed somewhat like the edge of a saw or comb; and the order, thus distinguished, is found wonderfully to agree with an order formed previously on another principle of classification, the Acanthopterygii, or thorny-finned order of Cuvier, excluding only the smooth-scaled families of this previously-formed division, and including, in addition to it, the flat fish. A third order, the Cycloidean, is marked by simple marginated scales, like those of the cod, haddock, whiting, herring, salmon, &c.; and this order is found to embrace chiefly the Malacopterygii; or soft-finned order of Cuvier—an order to which all these well-known fish, with an immense multitude of others, belong. Thus the results of the principle of classification adopted by Agassiz wonderfully agree with the results of the less simple principles adopted by Cuvier and the other masters in this department of Natural History. Now, it is peculiar to yet a fourth order, the Ganoidean, or shining-scaled order, that by much the greater number of the genera which it comprises exist only in the fossil state. At least five-sixths of the whole were ascertained to be extinct several years ago, at a time when the knowledge of fossil Ichthyology was much more limited than at present: the proportions are now found to be immensely greater on the side of the dead. And this order seems to have included all the semi-osseous, semi-cartilaginous icthyolites of the Lower Old Red Sandstone; the enamelled scale is the characteristic, according to Agassiz's principle of classification, of the existences that filled the gap so

often alluded to as existing in the present creation. All their scales glitter with enamel: they bore to this order the relation that the cartilaginous fish bear to the Placoidean order, the thorny-finned fish to the Ctenoidean order, and the soft-finned fish to the Cycloidean order. It also included, with the semi-cartilaginous, the sauroid fish—those master-existences and tyrants of the earlier vertebrata; and both classes find their representatives among the comparatively few ganoid fishes of the present creation; the one in the sturgeon family, which of all existing families approaches nearest in other respects to the extinct semi-cartilaginous fishes; the other in the sauroid genus *Lepidosteus*, to which the bony pike belongs. The head, back, and sides of the sturgeon are defended, as has been already remarked, by longitudinal rows of hard osseous bosses—the bony pike is armed with enamelled osseous scales, of a stony hardness. It seems a somewhat curious circumstance, that fishes so unlike each other in their internal frame-work, should thus resemble one another in their bony coverings, and in some slight degree in their structure of tail. One of the characteristics of sauroid fishes is the extreme compactness and hardness of their skeleton.*

* "The sauroid or lizard-like fishes," says Dr. Buckland, "combine in the structure, both of the bones and some of the soft parts, characters which are common to the class of reptiles. The bones of the skull are united by closer sutures than those of common fishes. The vertebræ articulate with the spinous processes of sutures, like the vertebræ of saurians; the ribs also articulate with the extremities of the spinous process. The caudal vertebræ have distinct chevron bones; and the general condition of the skeleton is stronger and more solid than in other fishes; the air

It requires skill such as that possessed by Agassiz, to determine that the uncouth *Coccosteus*, or the equally uncouth *Pterichthys*, of the Old Red Sandstone, with their long articulated tails and tortoise-like plates, were *bona fide* fishes; but there is no possibility of mistaking the *Osteolepis:* it is obvious to the least practised eye that it must have been a fish, and a handsome one. Even a cursory examination, however, shows very striking peculiarities, which are found, on further examination, to characterize not this family alone, but at least one-half the cotemporary families besides. We are accustomed to see vertebrated animals with the bone uncovered in one part only—that part the teeth—and with the rest of the skeleton wrapped up in flesh and skin. Among the reptiles we find a few exceptions; but a creature with a skull as naked as its teeth—the bone being merely covered, as in these, by a hard shining enamel—and with toes also of bare enamelled bone, would be deemed an anomaly in creation. And yet such was the condition of the *Osteolepis*, and many of its cotemporaries. The enamelled teeth were placed in jaws which presented outside a surface as naked and as finely enamelled as their own. (See Plate IV., fig. 5.) The entire head was covered with enamelled osseous plates, furnished inside like other bones, as shown by their cellular construction, with their nourishing blood-vessels, and perhaps their oil, and which rested apparently on the cartilaginous box, which must have enclosed the brain,

bladder also is bifid and cellular, approaching to the character of lungs; and in the throat there is a glottis, as in sirens and salamanders, and many saurians.—Note to *Bridgewater Treatise*, p. 274, first edit.

and connected it with the vertebral column. I cannot better illustrate the peculiar condition of the fins of this ichthyolite than by the webbed foot of a water-fowl. The web or membrane in all the aquatic birds with which we are acquainted, not only connects, but also covers the toes. The web or membrane in the fins of existing fishes accomplishes a similar purpose; it both connects and covers the supporting bones or rays. Imagine, however, a webbed foot in which the toes—connected, but not covered—present, as in skeletons, an upper and under surface of naked bone; and a very correct idea may be formed from such a foot, of the condition of fin which obtained among at least one-half the ichthyolites of the Lower Old Red Sandstone. The supporting bones or rays seem to have been connected laterally by the membrane; but on both sides they presented bony and finely-enamelled surfaces. (See Plate IV., fig. 6.) In this singular class of fish, all was bone without, and all was cartilage within; and the bone in every instance, whether in the form of jaws or of plates, of scales or of rays, presented an external surface of enamel.

The fins are quite a study. I have alluded to the connecting membrane. In existing fish this membrane is the principal agent in propelling the creature: it strikes against the water, as the membrane of the bat's wing strikes against the air; and the internal skeleton serves but to support and stiffen it for this purpose. But in the fin of the *Osteolepis*, as in those of many of its cotemporaries, we find the condition reversed. The rays were so numerous, and lay so thickly side by side, like feathers in the wing of a bird, that they

presented to the water a continuous surface of bone, and the membrane only served to support and bind them together. In the fins of existing fish we find a sort of bat-wing construction—in those of the *Osteolepis* a sort of bird-wing construction. The rays, to give flexibility to the organ which they compose, were all jointed, as in the soft-finned fish—as in the herring, salmon, and cod, for example; and we find in all the fins the anterior ray rising from the body in the form of an angular scale: it is a strong bony scale in one of its joints, and a bony ray in the rest. The characteristic is a curious one.

It is again necessary, in pursuing our description, to refer for illustration to the purely cartilaginous fishes. In at least all the higher orders of these, furnished with movable jaws, such as the sturgeon, the ray, and the shark, the mouth is placed far below the snout. The dog-fish and thorn-back are familiar instances. Further, the mouth in bony fishes is movable on both the upper and under side, like the beak of the parrot; in the higher cartilaginous fishes it is movable, as in quadrupeds, on the under side only. In all their orders, too, except in that of the sturgeon, the gills open to the water by detached spiracles or breathing holes; but in the sturgeon, as in the osseous fishes, there is a continuous linear opening, shielded by an operculum or gill-cover. In the *Osteolepis* the mouth opened below the snout, but not so far below it as in the purely cartilaginous fishes—not farther below it than in many of the osseous ones—than in the genus Aspro for instance, or than in the genus Polynemus, or in even the haddock or cod. It was thickly fur-

nished with slender and sharply-pointed teeth. I have hitherto been unable fully to determine whether, like the mouths of the osseous fishes, it was movable on both sides, though, from the perfect form of what seems to be the intermaxillary bone, I cannot avoid thinking it was. The gills opened, as in the osseous fishes, in continuous lines, and were covered by large bony opercules—that on the enamelled side somewhat resemble round japanned shields.

But while the head of the *Osteolepis*, with its appendages, thus resembled, in some points, the heads of the bony fishes, the tail, like those of most of its cotemporaries, differed in no respect from the tails of cartilaginous ones, such as the sturgeon. The vertebral column seems to have run on to well-nigh the extremity of the caudal fin, which we find developed chiefly on the under side. The tail was a one-sided tail. Take into account with these peculiarities—peculiarities such as the naked skull, jaws, and operculum, the naked and thickly-set rays, and the unequally lobed condition of tail—a body covered with scales that glitter like sheets of mica, and assume, according to their position, the parallelogrammical, rhomboidal, angular, or polygonal form—a lateral line raised, not depressed—a raised bar on the inner or bony side of the scales, which, like the doubled-up end of a tile, seems to have served the purpose of fastening them in their places—a general clustering of alternate fins towards the tail—and the *tout ensemble* must surely impart to the reader the idea of a very singular little fish. The ventral fins front the space which occurs between the two dorsals, and the anal

fin the space which intervenes between the posterior dorsal fin and the tail. The length of the *Osteolepis*, in my larger specimens, somewhat exceeds a foot; in the smaller it falls short of six inches. There exist at least three species of this ichthyolite, distinguished chiefly, in two of the instances, by the smaller and larger size of their scales, compared with the bulk of their bodies, and by punctulated markings on the enamel in the case of the third. This last, however, is no specific difference, but common to the entire genus, and to several other genera besides. The names are, *Osteolepis macrolepidotus*, *O. microlepidotus*, and *O. arenatus*.*

Next to the *Osteolepis* we may place the *Dipterus*, or double-wing, of the Lower Old Red Sandstone, an ichthyolite first introduced to the knowledge of geologists by Mr. Murchison, who, with his friend, Mr. Sedgwick, figured and described it in a masterly paper on the older sedimentary formations of the north of Scotland, which appeared in the *Transactions of the Geological Society of London* for 1828. The name, derived from its two dorsals, would suit equally well, like that of the *Osteolepis*, many of its more recently discovered cotemporaries. From the latter ichthyolite it differed chiefly in the position of its fins, which were opposite, not alternate; the double dorsals exactly fronting the anal and ventral fins. (See Plate V., fig. 1.) The *Diplopterus*, a nearly resembling ichthyolite of the same formation, also owes its

* To these there have since been added *Osteolepis major*, *O. intermedius*, and *O. nanus*—the two latter, however, Agassiz regards as doubtful.

PLATE V

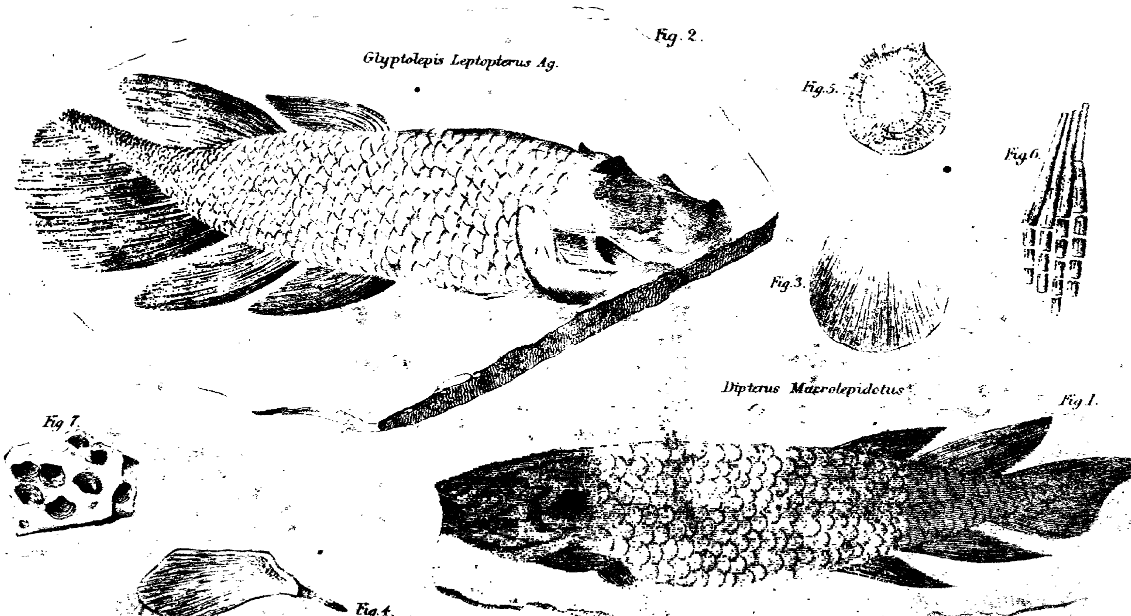


Fig. 2.
Glyptolepis Leptopterus Ag.
Fig. 5.
Fig. 6.
Fig. 3.
Dipterus Macrolepidotus.
Fig. 1.
Fig. 7.
Fig. 4.

name to the order and arrangement of it fins, which, like those of the *Dipterus*, were placed fronting each other, and in pairs. But the head, in proportion to the body, was in greater size than in either the *Dipterus* or *Osteolepis;* and the mouth, as indicated by the creature's length of jaw, must have been of much greater width. In their more striking characteristics, however, the three genera seem to have nearly agreed. In all alike, scales of bone glisten with enamel; their jaws, enamel without and bone within, bristle thick with sharp-pointed teeth; closely-jointed plates, burnished like ancient helmets, cover their heads, and seem to have formed a kind of outer table to skulls externally of bone and internally of cartilage; their gill-covers consist each of a single piece, like the gill-cover of the sturgeon; their tails were formed chiefly on the lower side of their bodies; and the rays of their fins, enamelled like their plates and their scales, stand up over the connecting membrane, like the steel or brass in that peculiar armour of the middle ages whose multitudinous pieces of metal were fastened together on a ground-work of cloth or of leather. All their scales, plates, and rays present a similar style of ornament. The shining and polished enamel is mottled with thickly-set punctures, or rather punctulated markings; so that a scale or plate, when viewed through a microscope, reminds one of the cover of a saddle. Some of the ganoid scales of Burdie House present surfaces similarly punctulated.*

* There exists, according to Agassiz, only a single species of *Dipterus—D. macrolepidotus;* whereas four species of *Diplopterus* have been enumerated—*D. affinis, D. borealis, D. macrocephalus*, and *D. Agassizii.* The existence of the last named,

The *Glyptolepis*, or carved scale, may be regarded as the representative of a family of the Lower Old Red Sandstone, which, differing very materially from the genera described, had yet many traits in common with them, such as the bare bony skull, the bony scales, the naked rays, and the unequally-sided condition of tail. The fins, which were of considerable length in proportion to their breadth of base, and present in some of the specimens a pendulous-like appearance, cluster thick together towards the creature's lower extremities, leaving the upper portion bare. There are two dorsals placed as in the *Dipterus* and *Diplopterus*—the anterior directly opposite the ventral fin, the posterior directly opposite the anal. The tail is long and spreading;—the rays, long and numerously articulated, are comparatively stout at their base, and slender as hairs where they terminate. The shoulder-bones are of huge dimensions, the teeth extremely minute. But the most characteristic parts of the creature are the scales. They are of great size compared with the size of the animal. An individual not more than half a foot in length, the specimen figured (see Plate V., fig. 2), exhibits scales fully three-eighth parts of an inch in diameter. In another more broken specimen there are scales a full inch across, and yet the length of the ichthyolite to which they belonged seems not to have much exceeded a foot and a half. Each scale consists of a double plate, an inner and an outer. The structure of the inner is not peculiar to the family or the formation: it is

however, as a distinct species, is regarded as problematical by the distinguished naturalist whose name has been affixed to it.

formed of a number of minute concentric circles, crossed by still minuter radiating lines—the one described, and the other proceeding from a common centre. (See Plate V., fig. 5.) All scales that receive their accessions of growth equally at their edges, exhibit internally a corresponding character. The outer plate presents an appearance less common. It seems relieved into ridges that drop adown it like sculptured threads, some of them entire, some broken, some straight, some slightly waved (see Plate V., fig. 3); and hence the name of the ichthyolite. The plates of the head were ornamented in a similar style, but their threads are so broken as to present the appearance of dotted lines, the dots all standing out in bold relief. My collection contains three varieties of this family; one of them disinterred from out the Cromarty beds about seven years ago, and the others only a little later, though, partly from the inadequacy of a written description, through which I was led to confound the *Osteolepis* with the *Diplopterus*, and to regard the *Glyptolepis* as the *Osteolepis*, I was not aware until lately that the discovery was really such; and under the latter name I described the creature in the *Witness* newspaper several weeks ere it had received the name which it now bears. It was first introduced to the notice of Agassiz in autumn last by Lady Cumming of Altyre. The species, however, was a different one from any yet found at Cromarty.*

The *Cheirolepis*, or scaly pectoral, forms the repre-

* There are three species of Glyptolepis—*G. elegans*, *G. leptopterus*, and *G. microlepidotus.*

sentative of yet another family of the Lower Old Red Sandstone, and one which any eye, however unpractised, could at once distinguish from the families just described. Professor Traill of the University of Edinburgh, a gentleman whose researches in Natural History have materially extended the boundaries of knowledge, and whose frankness in communicating information is only equalled by his facility in acquiring it, was the first discoverer of this family, one variety of which, the *Cheirolepis Traillii*, bears his name. The figured specimen (Plate VI., fig. 1) Agassiz has pronounced a new species, the discovery of the writer. In all the remains of this curious fish which I have hitherto seen, the union of the osseous with the cartilaginous, in the general frame-work of the creature, is strikingly apparent. The external skull, the great shoulder-bone, and the rays of the fins, are all unequivocally osseous; the occipital and shoulder-bones, in particular, seem of great strength and massiveness, and are invariably preserved, however imperfect the specimen in other respects; whereas, even in specimens the most complete, and which exhibit every scale and every ray, however minute, and show unchanged the entire outline of the animal, not a fragment of the internal skeleton appears. The *Cheirolepis* seems to have varied from fourteen to four inches in length. When seen in profile, the under line, as in the figured variety, seems thickly covered with fins, and the upper line well-nigh naked. The large pectorals almost encroach on the ventral fins, and the ventrals on the anal fin; whereas the back, for two-thirds the entire length of the creature, presents a bare

Cheirolepis Cummingiæ. Ag.

Fig. 1.

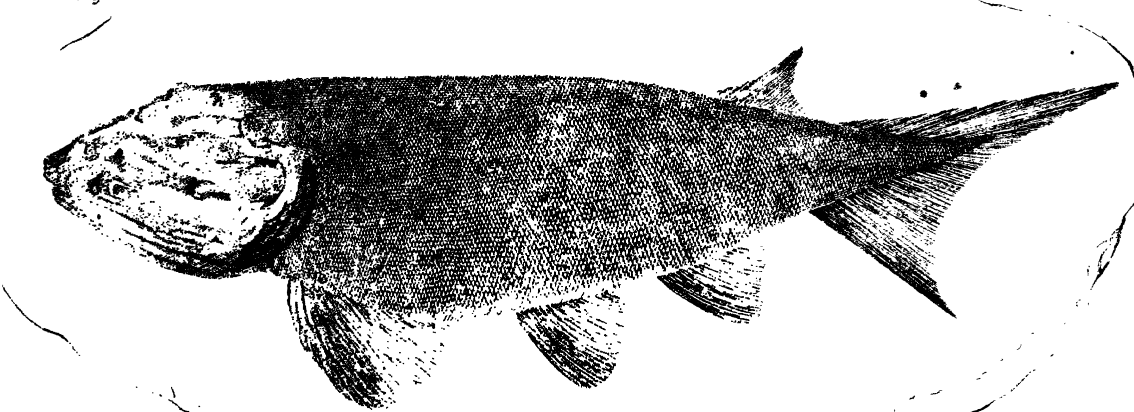


Fig. 2.

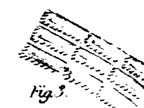


Fig. 3.

rectilinear ridge, and the single dorsal, which rises but a little way over the tail, immediately opposite the posterior portion of the anal fin, is comparatively of small size. The tail, which, in the general condition of being developed chiefly on the lower side, resembles the tails of all the creature's cotemporaries, is elegantly lobed. The scales, in proportion to the bulk of the body which they cover, are not more than one-twentieth the size of those of the *Osteolepis*. They are richly enamelled, and range diagonally from the shoulder to the belly in waving lines; and so fretted is each individual scale by longitudinal grooves and ridges, that on first bringing it under the glass, it seems a little bunch of glittering thorns, though, when more minutely examined, it is found to present somewhat the appearance of the outer side of the deep-sea cockle, with its strongly-marked ribs and channels, the point in which the posterior point terminates representing the hinge. (See Plate VI., fig. 2.) The bones of the head, enamelled like the scales, are carved into jagged inequalities, somewhat resembling those on the skin of the shark, but more irregular. The sculpturings seem intended evidently for effect. To produce harmony of appearance between the scaly coat and the enamelled occipital plates of bone, the surfaces of the latter are relieved, where they border on the shoulders, into what seem scales, just as the dead walls of a building are sometimes, for the sake of uniformity, wrought into blind windows. The enamelled rays of the fins are finished, if I may so speak, after the same style. They lie thick upon one another as the fibres of a quill, and like these, too,

they are imbricated on the sides, so that the edge of each seems jagged into a row of prickles. (See Plate VI., fig. 3.) The jaws of the *Cheirolepis* were armed with thickly-set sharp teeth, like those of its cotemporaries, the *Osteolepis* and *Diplopterus*.*

* There have been five species of Cheirolepis enumerated—*C. Cummingiæ*, *C. splendens*, *C. Trailii*, *C. unilateralis*, and *C. Uragus*. The *Cheirolepis splendens* and *C. unilateralis* Agassiz regards as doubtful.

CHAPTER V.

The Classifying Principle, and its Uses—Three Groups of Ichthyolites among the Organisms of the Lower Old Red Sandstone—Peculiarities of the Third Group—Its Varieties—Description of the *Cheiracanthus*—Of two unnamed Fossils of the same Order—Microscopic Beauty of these Ancient Fish—Various Styles of Ornament which obtain among them—The Molluscs of the Formation—Remarkable chiefly for the Union of Modern with Ancient Forms which they exhibit—Its Vegetables—Importance and Interest of the Record which it furnishes.

THERE rests in the neighbourhood of Cromarty, on the upper stratum of one of the richest ichthyolite beds I have yet seen, a huge water-rolled boulder of granitic gneiss, which must have been a traveller, in some of the later periods of geological change, from a mountain range in the interior highlands of Ross-shire, more than sixty miles away. It is an uncouth-looking mass, several tons in weight, with a flat upper surface, like that of a table; and as a table, when engaged in collecting my specimens, I have often found occasion to employ it. I have covered it over, times without number, with fragments of fossil fish—with plates, and scales, and jaws, and fins, and, when the search proved successful, with entire ichthyolites.

Why did I always arrange them, almost without thinking of the matter, into three groups? Why, even when the mind was otherwise employed, did the fragments of the *Coccosteus* and *Pterichthys* come to occupy one corner of the stone, and those of the various fish just described another corner, and the equally well-marked remains of a yet different division a third corner? The process seemed almost mechanical, so little did it employ the attention, and so invariable were the results. The fossils of the surrounding bed always found their places on the huge stone in three groups, and at times there was yet a fourth group added—a group whose organisms belonged not to the animal, but the vegetable kingdom. What led to the arrangement, or in what did it originate? In a principle inherent in the human mind—that principle of classification which we find pervading all science—which gives to each of the many cells of recollection its appropriate facts—and without which all knowledge would exist as a disorderly and shapeless mass, too huge for the memory to grasp, and too heterogeneous for the understanding to employ. I have described but two of the groups, and must now say a very little about the principle on which, justly or otherwise, I used to separate the third, and on the distinctive differences which rendered the separation so easy.

The recent bony fishes are divided, according to the Cuvierian system of classification, into two great orders, the soft-finned and the thorny-finned order—the *Malacopterygii* and the *Acanthopterygii*. In the former the rays of the fins are thin, flexible, articulated,

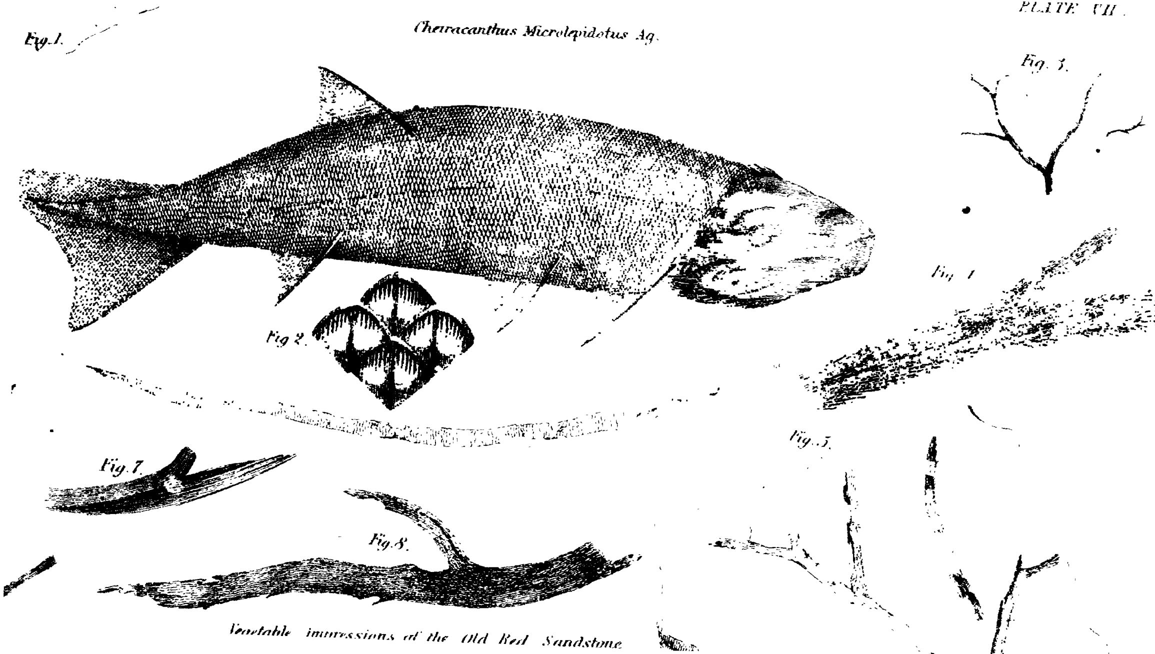
branched; each ray somewhat resembles a jointed bamboo, with this difference, however, that what seems a single ray at bottom, branches out into three or four rays atop. In the latter (the thorny-finned order)—especially in their anterior dorsal, and perhaps anal fins—the rays are stiff continuous spikes of bone, and each stands detached as a spear, without joint or branch. The perch may be instanced as a familiar illustration of this order—the gold-fish of the other. Now, between the fins of two sets—shall I venture to say orders?—of the ichthyolites of the Lower Old Red Sandstone, an equally striking difference obtains. The fin of the *Osteolepis*, with its surface of enamelled and minutely-jointed bones, I have already described as a sort of bird-wing fin. The naked rays, with their flattened surfaces, lay thick together as feathers in the wing of a bird—so thick as to conceal the connecting membrane; and fins of similar construction characterized the families of the *Dipterus*, *Diplopterus*, *Glyptolepis*, *Cheirolepis*, *Holoptychius*, and, I doubt not, many other families of the same period, which await the researches of future discoverers. But the fins of another set of ichthyolites, their cotemporaries, may be described as bat-wing fins: they presented to the water a broad expanse of membrane; and the solitary ray which survives in each was not a jointed, but a continuous spear-like ray. The fins of this set, or order, are thorny fins, like those of the *Acanthopterygii;* the anterior edge of each, with the exception of perhaps the caudal fin, which differs in construction from the others, is composed of a strong bony spike. Such, with some tacit reference,

perhaps, to the similar Cuvierian principle of classification, were the distinctive differences, on the strength of which I used to arrange two of my groups of fossils on the granitic boulder; and the influence of the same principle, almost instinctively exerted—for in writing the previous pages I scarce thought of its existence—has, I find, given to each group its own chapter.

Of the membranous-finned and thorny-rayed order of ichthyolites, the *Cheiracanthus*, or thorny-hand (*i.e.*, pectoral), may be regarded as an adequate representative. (See Plate VII., fig. 1.) The *Cheiracanthus* must have been an eminently handsome little fish—slim, tapering, and described in all its outlines, whether of the body or the fins, by gracefully-waved lines. It is, however, a rare matter to find it presenting its original profile in the stone;—none of the other ichthyolites are so frequently distorted as the *Cheiracanthus*. It seems to have been more a cartilaginous and less an osseous fish than most of its cotemporaries. However perfect the specimen, no part of the internal skeleton is ever found, not even when scales as minute as the point of a pin are preserved, and every spine stands up in its original place. And hence, perhaps, a greater degree of flexibility, and consequent distortion. The body was covered with small angular scales, brightly enamelled, and delicately fretted into parallel ridges that run longitudinally along the upper half of the scale, and leave the posterior portion of it a smooth glittering surface. (See Plate VII., fig. 2.) They diminish in size towards the head, which, from the faint stain left on the stone, seems to have been composed

PLATE VII.

Cheiracanthus Microlepidotus Ag.



Vegetable impressions of the Old Red Sandstone

of cartilage exclusively, and either covered with skin or with scales of extreme minuteness. The lower edge of the operculum bears a tagged fringe, like that of a curtain. The tail, a fin of considerable power, had the unequal-sided character common to the formation; and the slender and numerous rays on both sides are separated by so many articulations as to present the appearance of parallelogrammical scales. The other fins are comparatively of small size. There is a single dorsal placed about two-thirds the entire length of the creature adown the back; and exactly opposite its posterior edge is the anterior edge of the anal fin. The ventral fins are placed high upon the belly, somewhat like those of the perch; the pectorals only a little higher. But it is rather in the construction of the fins than their position that the peculiarities of the *Cheiracanthus* are most marked. The anterior edge of each, as in the pectorals of the existing genera *Cestracion* and *Chimæra*, is formed of a strong large spine. In the *Chimæra Borealis*, a cartilaginous fish of the Northern Ocean, the spine seems placed in front of the weaker rays, just, if I may be allowed the comparison, as, in a line of mountaineers engaged in crossing a swollen torrent, the strongest man in the party is placed on the upper side of the line, to break off the force of the current from the rest. In the *Cheiracanthus*, however, each fin seems to consist of but a single spine, with an angular membrane fixed to it by one of its sides, and attached to the creature's body on the other. Its fins are masts and sails—the spine representing the mast, and the membrane the sail; and it is a curious characteristic of the order,

that the membrane, like the body, of the ichthyolite, is thickly covered with minute scales. The mouth seems to have opened a very little under the snout, as in the haddock; and there are no indications of its having been furnished with teeth.*

An ichthyolite first discovered by the writer about three years ago, and introduced by him to the notice of Agassiz during his recent visit to Edinburgh, but still unfurnished with a name,† is a still more striking representative of this order than even the *Cheiracanthus*. It must have been proportionally thick and short, like some of the tropical fishes, though rather handsome than otherwise. (See Plate VIII., fig. 1.) The scales, minute, but considerably larger than those of the *Cheiracanthus*, are of a rhomboidal form, and so regularly striated—the striæ converging to a point at the posterior termination of each scale—that when examined with a glass, the body appears as if covered with scallops. (See Plate VIII., fig. 3.) It seems a piece of exquisite shell-work, such as we sometimes see on the walls of a grotto. There are two dorsals—the posterior, immediately over the tail, and directly opposite the anal fin; the anterior, somewhat higher up than the ventrals; and all the fins are of great size. The anterior edge of each is formed of a strong spine, round as the handle of a halbert, and diminishing gradually and symmetrically to a sharp point. Though formed externally of solid bone, it seems to

* There have been three species of *Cheiracanthus* determined—*C. microlepidotus*, *C. minor*, and *C. Murchisoni*.

† Now determined to be a species of *Diplacanthus D. longispinus*.

D. Striatus

Fig. 2.

NEW

Fig. 4

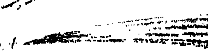


Fig. 1.

Diplacanthus Longispinus Ag.

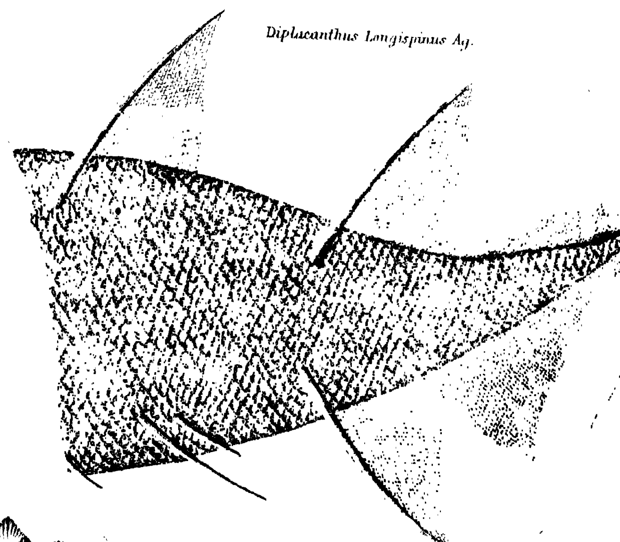


Fig. 3.

have been composed internally of cartilage, like the bones of some of the osseous fishes—those of the halibut for instance; and the place of the cartilage is generally occupied in the stone by carbonate of lime. The membrane which formed the body of the fin was covered, like that of the *Cheiracanthus*, with minute scales, of the same scallop-like pattern with the rest, but of not more than one-sixth the size of those which cover the creature's sides and back. Imagine two lug-sails stiffly extended between the deck of a brigantine and her two masts, the latter raking as far aft as to form an angle of sixty degrees with the horizon, and some idea may be formed of the dorsals of this singular fish. They were lug-sails, formed not to be acted upon by the air, but to act upon the water. None of my specimens show the head; but judging from analogies furnished by the other families of the group, I entertain little doubt that it will be found to be covered, not by bony plates, but by minute scales, diminishing, as they approach the snout, into mere points. In none of the specimens does any part of the internal skeleton survive.

My collection contains the remains of yet another fish of this group, which was unfurnished with a name only a few months ago, but which I first discovered about five years since. (See Plate VIII., fig. 2.) It is now designated the *Diplacanthus;* and though the smallest ichthyolite of the formation yet known, it is by no means the least curious. The length from head to tail in some of my specimens does not exceed three inches; the largest fall a little short of five. The scales, which are of such extreme minuteness

that their peculiarities can be detected by only a powerful glass, resemble those of the *Cheiracanthus;* but the ridges are more waved, and seem, instead of running in nearly parallel lines, to converge toward the apex. There are two dorsals, the one rising immediately from the shoulder, a little below the nape; the other directly opposite the anal fin. The ventrals are placed near the middle of the belly. There is a curious mechanism of shoulder-bone involved with a lateral spine and with the pectorals. The creature, unlike the *Cheiracanthus*, seems to have been furnished with jaws of bone: there are fragments of bone upon the head, tuberculated apparently on the outer surface; and minute cylinders of carbonate of lime running along all the larger bones, where we find them accidently laid open, show that they were formed on internal bases of cartilage. But the best-marked characteristic of the creature is furnished by the spines of its fins, which are of singular beauty. Each spine resembles a bundle of rods, or rather, like a Gothic column, the sculptured semblance of a bundle of rods, which finely diminish towards a point, sharp and tapering as that of a rush. (See Plate VIII., fig. 4.)* The rest of the fin presents the appearance of a mere scaly membrane, and no part of the internal skeleton appears. Perhaps this last circumstance, common to all the ichthyolites of the formation, if we except the families of the *Coccosteus* and *Pterichthys*, may throw some light on the apparently membraneous condition of fin peculiar to the families of this order.

* Agassiz reckons four species of *Diplacanthus*—*D. crassispinus*, *D. longispinus*, *D. striatulus*, and *D. striatus.*

What appears in the fossil a mere scaly membrane attached to a single spine of bone, may have had in the living animal a cartilaginous frame-work, like the fins of the dog-fish and thorn-back, that are amply furnished with rays of cartilage—though, of course, all such rays must have disappeared in the stone, like the rest of the internal skeleton. Unquestionably the caudal fin of the two last described fossils must have been strengthened by some such internal framework; for, as they differ from the other fins in being unprovided with osseous spines, they would have formed, without an internal skeleton, mere pendulous attachments, altogether unfitted to serve the purpose of instruments of motion. There may be found in the bony spines of all this order direct proof that, had there been an internal skeleton of bone, it would have survived. The spines run deep into the body, as a ship's masts run deep into her hulk; and we can see them standing up among the scales to their termination, in such bold relief, that, from a sort of pictorial illusion, they seem as if fixed to the creature's sides, and foreshortened, instead of rising in profile from its back or belly. (See Plate VIII., fig. 1.) The observer will of course remember, that in the living animal the view of the spine must have terminated with the line of the profile, just as the view of a vessel's mast terminates with the deck, though the mast itself penetrates to the interior keel. Now it must be deemed equally obvious, that had the vertebral column been of bone, not of cartilage, instead of exhibiting no trace, even the faintest, of having ever existed, it would have stood out in as high relief as the internal butts or

stocks of the spines. And such are the general characteristics of a few of the ichthyolites of this lower formation of the Old Red Sandstone—a few of the more striking forms, sculptured, if I may so speak, on the middle compartment of the Caithness pyramid. It would be easy rendering the list more complete at even the present stage, when the field is still so new that almost every labourer in it can exhibit genera and species unknown to his brother labourers. The remains of a species of *Holoptychius* have been discovered low in the formation, at Orkney, by Dr. Traill; similar remains have been found in it at Gamrie. In its upper beds the specimens seem so different from those in the lower, that in extensive collections made from the inferior strata of one locality, Agassiz has been unable to identify a single specimen with the specimens of collections made from the superior strata of another, though the genera are the same. Meanwhile there are heads and hands at work on the subject; Geology has become a Briareus; and I have little doubt that in five years hence this third portion of the Old Red Sandstone will be found to contain as many distinct varieties of fossil fish as the whole geological scale was known to contain fifteen years ago.*

There is something very admirable in the consis-

* This prediction has been already more than accomplished. At the death of Cuvier in 1832, there were but ninety-two species of fossil fish known to the geologist; Agassiz now enumerates one hundred and five species that belong to the Old Red Sandstone alone; and if we include doubtful species, on which he has not authoritatively decided—some of which, however, were included in the list of Cuvier—one hundred and fifty-one.

tency of style which obtains among the ichthyolites of this formation. In no single fish of either group do we find two styles of ornament—in scarce any two fishes do we find exactly the same style. I pass fine buildings almost every day. In some there is a discordant jumbling—an Egyptian Sphynx, for instance, placed over a Doric portico; in all there prevails a vast amount of timid imitation. The one repeats the other, either in general outline or in the subordinate parts. But the case is otherwise among the ichthyolites of the Old Red Sandstone; nor does it lessen the wonder, that their nicer ornaments should yield their beauty only to the microscope. There is unity of character in every scale, plate, and fin—unity such as all men of taste have learned to admire in those three Grecian orders from which the ingenuity of Rome was content to borrow, when it professed to invent—in the masculine Doric, the chaste and graceful Ionic, the exquisitely elegant Corinthian; and yet the unassisted eye fails to discover the finer evidences of this unity: it would seem as if the adorable Architect had wrought it out in secret with reference to the Divine idea alone. The artist who sculptured the cherry-stone consigned it to a cabinet, and placed a microscope beside it; the microscopic beauty of these ancient fish was consigned to the twilight depths of a primeval ocean. There is a feeling which at times grows upon the painter and the statuary, as if the perception and love of the beautiful had been sublimed into a kind of moral sense. Art comes to be pursued for its own sake; the exquisite conception in the mind, or the elegant and elaborate

model, becomes all in all to the worker, and the dread of criticism or the appetite of praise almost nothing. And thus, through the influence of a power somewhat akin to conscience, but whose province is not the just and the good, but the fair, the refined, the exquisite, have works prosecuted in solitude, and never intended for the world, been found fraught with loveliness. Sir Thomas Lawrence, when finishing, with the most consummate care, a picture intended for a semi-barbarous foreign court, was asked why he took so much pains with a piece destined, perhaps, never to come under the eye of a connoisseur. "I cannot help it," he replied; "I do the best I can, unable, through a tyrant feeling, that will not brook offence, to do anything less." It would be perhaps over-bold to attribute any such o'ermastering feeling to the Creator; yet certain it is, that among his creatures well-nigh all approximations towards perfection, in the province in which it expatiates, owe their origin to it, and that Deity in all his works is his own rule.

The *Osteolepis* was cased, I have said, from head to tail, in complete armour. The head had its plaited mail, the body its scaly mail, the fins their mail of parallel and jointed bars; the entire suit glittered with enamel; and every plate, bar, and scale, was dotted with microscopic points. Every ray had its double or treble punctulated row, every scale or plate its punctulated group; the markings lie as thickly in proportion to the fields they cover, as the circular perforations in a lace veil; and the effect, viewed through the glass, is one of lightness and beauty. In the *Cheirolepis* an entirely different style obtains. The

enamelled scales and plates glitter with minute ridges, that show like thorns in a December morning varnished with ice. Every ray of the fins presents its serrated edge, every occipital plate and bone its sculptured prominences, every scale its bunch of prickle-like ridges. A more rustic style characterized the *Glyptolepis*. The enamel of the scales and plates is less bright; the sculpturings are executed on a larger scale, and more rudely finished. The relieved ridges, waved enough to give them a pendulous appearance, drop adown the head and body. The rays of the fins, of great length, present also a pendulous appearance. The bones and scales seem disproportionately large. There is a general rudeness in the finish of the creature, if I may so speak, that reminds one of the tatooings of a savage, or the corresponding style of art in which he ornaments the handle of his stone-hatchet or his war-club. In the *Cheiracanthus*, on the contrary, there is much of a minute and cabinet-like elegance. The silvery smoothness of the fins, dotted with scarcely visible scales, harmonized with a similar appearance of head; a style of sculpture resembling the parallel etchings of the line-engraver fretted the scales; the fins were small, and the contour elegant. I have already described the appearance of the unnamed fossils—the seeming shell-work that covered the sides of the one—its mast-like spines and sail-like fins; and the Gothic-like peculiarities that characterized the other—its rodded, obelisk-like spines, and the external frame-work of bone that stretched along its pectorals.

Till very lately it was held that the Old Red Sandstone of Scotland contained no mollusca. It seemed

difficult, however, to imagine a sea abounding in fish, and yet devoid of shells. In all my explorations, therefore, I had an eye to the discovery of the latter, and on two several occasions I disinterred what I supposed might have formed portions of a cardium or terebratula. On applying the glass, however, the punctulated character of the surface showed that the supposed shells were but parts of the concave helmet-like plate that covered the snout of the *Osteolepis*. In the ichthyolite beds of Cromarty and Ross, of Moray, Banff, Perth, Forfar, Fife, and Berwickshire, not a single shell has yet been found; but there have been discovered of late, in the upper beds of the Lower Old Red Sandstone in Orkney, the remains of a small delicate bivalve, not yet described or figured, but which very much resembles a *Venus*. (See Plate V. fig. 7.) In the Tilestones of England, so carefully described by Mr. Murchison in his *Silurian System*, shells are very abundant; and the fact may now be regarded as established, that the Tilestones of England belong to a deposit contemporaneous with the ichthyolite beds of Caithness and Cromarty. They occupy the same place low in the base of the Old Red; and there is at least one ichthyolite common to both,* and which does not occur in the superior strata of the system in either country—the *Dipterus Macrolepidotus*. The evidence that the fish and shells lived in the same period, and represent therefore the same formation, may be summed up in a single sentence. We learn from the geology of Caithness that this species of *Dip-*

* *Silurian System*, part ii., p. 599.

terus was unquestionably cotemporary with all the other ichthyolites described;—we learn from the geology of Herefordshire that the shells were as unquestionably cotemporary with it.* These—the shells—are of a singularly mixed character, regarded as a group, uniting, says Mr. Murchison, forms at one time deemed characteristic of the more modern formations—of the later secondary, and even tertiary periods—with forms the most ancient, and which characterize the molluscous remains of the transition rocks. Turbinated shells and bivalves of well-nigh the recent type may be found lying side by side with chambered Orthoceratites and Terebratula.†

The vegetable remains of the formation are numerous but obscure, consisting mostly of carbonaceous markings, such as might be formed by comminuted sea-weed. (See Plate VII.) Some of the impressions fork into branches at acute angles (see figs. 4, 5, and 6); some affect a waved outline (see figs. 7 and 8); most of them, however, are straight and undivided. They lie in some places so thickly in layers as to give the stone in which they occur a slaty character. One of my specimens shows minute markings, somewhat resembling the bird-like eyes of the Stigmaria Ficoides of the Coal Measures;—the branches of another terminate in minute hooks, that remind one of the hooks of the young tendrils of the pea when they first begin to turn. (See fig. 3.) In yet another there are marks

* In Russia, too, as shown by the recent discoveries of Murchison, the Old-Red fishes of Caithness, and the Old-Red shells of Devonshire, may be found lying embedded in the same strata.

† *Silurian System*, part i., p. 183.

of the ligneous fibre; when examined by the glass, it resembles a bundle of horse-hairs lying stretched in parallel lines; and in this specimen alone have I found aught approaching to proof of a terrestrial origin. The deposition seems to have taken place far from land; and this lignite, if in reality such, had probably drifted far ere it at length became weightier than the supporting fluid, and sank.* It is by no means rare to find fragments of wood that have been borne out to sea by the gulf-stream from the shores of Mexico or the West Indian islands, stranded on the rocky coasts of Orkney and Shetland.

The dissimilarity which obtains between the fossils of the cotemporary formations of this system in England and Scotland is instructive. The group in the one consists mainly of molluscous animals—in the other, almost entirely of ichthyolites, and what seems to have been algæ. Other localities may present us with yet different groups of the same period—with

* The organism here referred to has been since slit by the lapidary, and the sections carefully examined. It proves to be unequivocally a true wood of the coniferous class. The following is the decision regarding it of Mr. William Nicol of Edinburgh, confessedly one of our highest living authorities in that division of fossil botany which takes cognizance of the internal structure of lignites, and decides from their anatomy their race and family:—

Edinburgh, 19th July, 1845.

DEAR SIR,—I have examined the structure of the fossil wood which you found in the Old Red Sandstone at Cromarty, and have no hesitation in stating, that the reticulated texture of the transverse sections, though somewhat compressed, clearly indicates a coniferous origin; but as there is not the slightest trace of a disc to be seen in the longitudinal sections parallel to the medullary rays, it is impossible to say whether it belongs to the Pine or Araucarian division.—I am, &c.,

WILLIAM NICOL.

the productions of its coasts, its lakes, and its rivers. At present we are but beginning to know just a little of its littoral shells, and of the fish of its profounder depths. These last are surely curious subjects of inquiry. We cannot catechise our stony ichthyolites, as the necromantic lady of the *Arabian Nights* did the coloured fish of the lake, which had once been a city, when she touched their dead bodies with her wand, and they straightway raised their heads and replied to her queries. We would have many a question to ask them if we could—questions never to be solved. But even the contemplation of their remains is a powerful stimulant to thought. The wonders of Geology exercise every faculty of the mind—reason, memory, imagination; and though we cannot put our fossils to the question, it is something to be so aroused as to be made to put questions to one's self. I have referred to the consistency of style which obtained among these ancient fishes—the unity of character which marked every scale, plate, and fin of every various family, and which distinguished it from the rest; and who can doubt that the same shades of variety existed in their habits and their instincts? We speak of the infinity of Deity—of His inexhaustible variety of mind; but we speak of it until the idea becomes a piece of mere common-place in our mouths. It is well to be brought to feel, if not to conceive of it—to be made to know that we ourselves are barren-minded, and that in Him "all fulness dwelleth." Succeeding creations, each with its myriads of existences, do not exhaust Him. He never repeats himself. The curtain drops at his com-

mand over one scene of existence full of wisdom and beauty—it rises again, and all is glorious, wise, and beautiful as before, and all is new. Who can sum up the amount of wisdom whose record He has written in the rocks—wisdom exhibited in the succeeding creations of earth, ere man was, but which was exhibited surely not in vain? May we not say with Milton—

> Think not though men were none,
> That heaven could want spectators, God want praise;
> Millions of spiritual creatures walk the earth,
> And these with ceaseless praise his works behold?

It is well to return on the record, and to read in its unequivocal characters the lessons which it was intended to teach. Infidelity has often misinterpreted its meaning, but not the less on that account has it been inscribed for purposes alike wise and benevolent. Is it nothing to be taught with a demonstrative evidence which the metaphysician cannot supply, that races are not eternal—that every family had its beginning, and that whole creations have come to an end?

CHAPTER VI.

The Lines of the Geographer rarely right Lines—These last, however, always worth looking at when they occur—Striking instance in the Line of the Great Caledonian Valley—Indicative of the Direction in which the Volcanic Agencies have operated—Sections of the Old Red Sandstone furnished by the Granitic Eminences of the Line—Illustration—Lias of the Moray Frith—Surmisings regarding its original Extent—These lead to an Exploratory Ramble—Narrative—Phenomena exhibited in the course of half an hour's Walk—The little Bay—Its Strata and their Organisms.

THE natural boundaries of the geographer are rarely described by right lines. Wherever these occur, however, the geologist may look for something remarkable. There is one very striking example furnished by the north of Scotland. The reader, in consulting a map of the kingdom, will find that the edge of a ruler laid athwart the country in a direction from south-west to north-east, touches the whole northern side of the great Caledonian Valley, with its long straight line of lakes—and onwards, beyond the valley's termination at both ends, the whole northern side of Loch Eil and Lòch Linnhe, and the whole of the abrupt and precipitous northern shores of the Moray Frith, to the extreme point of Tarbat Ness—a right line of

considerably more than a hundred miles. Nor does the geography of the globe furnish a line better defined by natural marks. There is both rampart and fosse. On the one hand we have the rectilinear lochs and lakes, with an average profundity of depth more than equal to that of the German Ocean, and, added to these, the rectilinear lines of frith; on the other hand, with but few interruptions, there is an inclined wall of rock, which rises at a steep angle in the interior to nearly two thousand feet over the level of the Great Canal, and overhangs the sea towards its northern termination, in precipices of more than a hundred yards.*

The direction of this rampart and fosse—this Roman wall of Scottish geological history—seems to have been that in which the volcanic agencies chiefly operated in upheaving the entire island from the abyss. The line survives as a sort of foot-track, hollowed by the frequent tread of earthquakes, to mark the course in which they journeyed. Like one of the great lines in a trigonometrical survey, it enables us, too, to describe the lesser lines, and to determine their average bearing. *The volcanic agencies must have extended athwart the country from south-west to north-east.* Mark in a map of the island—all the better if it be a geological one—the line in which most of our mountain ranges stretch across from the German Ocean to the Atlantic—the line, too, in which our friths, lochs, and bays, on both the eastern and west-

* The valley of the Jordan, from the village of Laish to the southern extremity of the Dead Sea, furnishes another very remarkable instance of a geographical right line.

ern coasts, and especially those of the latter, run into the interior. Mark, also, the line of the geological formations, where least broken by insulated groups of hills—the line, for instance, of the Old Red Sandstone belt, which flanks the southern base of the Grampians—the nearly parallel line of our Scottish Coal-field, in its course from sea to sea—the line of the Grauwacke, which forms so large a portion of the south of Scotland—the line of the English Coal-field, of the Lias, of the Oolite, of the chalk—and how in this process of diagonal lining, if I may so speak, the south-eastern portion of England comes to be cut off from the secondary formations altogether, and, but for the denudation of the valley of the Weald, would have exhibited only tertiary depositions. In all these lines, whether of mountains, lakes, friths, or formations, there is an approximation to parallelism with the line of the great Caledonian Valley—proofs that the upheaving agency from beneath must have acted in this direction from some unknown cause, during all the immensely-extended term of its operations, and along the entire length of the island. It is a fact not unworthy of remark, that the profound depths of Loch Ness undulated in strange sympathy with the reeling towers and crashing walls of Lisbon, during the great earthquake of 1755; and that the impulse, true to its ancient direction, sent the waves in huge furrows to the north-east and the south-west.

The north-eastern portion of this rectilinear wall or chain runs, for about thirty miles, through an Old Red Sandstone district. The materials which compose it are as unlike those of the plain out of which

it arises, as the materials of a stone-dike running half-way into a field are unlike the vegetable mould which forms the field's surface. The ridge itself is of a granitic texture—a true gneiss. At its base we find only conglomerates, sandstones, shales, and stratified clays, and these lying against it in very high angles. Hence the geological interest o this lower portion of the wall. As has been shrewdly remarked by Mr. Murchison,* in one of his earlier papers, the gneiss seems to have been forced through the sandstone from beneath, in a solid, not a fluid form; and as the ridge atop is a narrow one, and the sides remarkably abrupt—an excellent wedge both in consistency and form—instead of having acted on the surrounding depositions, as most of the south-country traps have done that have merely issued from a vent, and overlaid the upper strata, it has torn up the entire formation from the very bottom. Imagine a large wedge forced from below through a sheet of thick ice on a river or pond. First the ice rises in an angle, that becomes sharper and higher as the wedge rises; then it cracks and opens, presenting its upturned edges on both sides, and through comes the wedge. And this is a very different process, be it observed, from what takes place when the ice merely cracks, and the water issues through the crack. In the one case there is a rent, and water diffused over the surface;—in the other there is the projecting wedge, flanked by the upturned edges of the ice; and these edges, of course, serve as indices to decide regarding

* See *Transactions of the London Geological Society* for 1828, p. 354.

the ice's thickness, and the various layers of which it is composed. Now, such are the phenomena exhibited by the wedge-like granitic ridge. The Lower Old Red Sandstone, tilted up against it on both sides at an angle of about eighty, exhibits in some parts a section of well-nigh two thousand feet, stretching from the lower conglomerate to the soft unfossiliferous sandstone, which forms in Ross and Cromarty the upper beds of the formation. There is a mighty advantage to the geologist in this arrangement. When books are packed up in a deep box or chest, we have to raise the upper tier ere we can see the tier below, and this second tier ere we can arrive at a third, and so on to the bottom. But when well arranged on the shelves of a library, we have merely to run the eye along their lettered backs, and we can thus form an acquaintance with them at a glance, which in the other case would have cost us a good deal of trouble. Now, in the neighbourhood of this granitic wedge, or wall, the strata are arranged, not like books in a box —such was their original position—but like books on the shelves of a library. They have been unpacked and arranged by the uptilting agent; and the knowledge of them, which could only have been attained in their first circumstances by perforating them with a shaft of immense depth, may now be acquired simply by passing over their edges. A morning's saunter gives us what would have cost, but for the upheaving granite, the labour of a hundred miners for five years.

By far the greater portion of the life of the writer was spent within less than half an hour's walk of one

of these upturned edges. I have described the granitic rock, with reference to the disturbance it has occasioned as a wedge forced from below, and with reference to its rectilinear position in the sandstone district which it traverses, as a stone-wall running half-way into a field. It may communicate a still correcter and livelier idea to think of it as a row of wedges, such as one sometimes sees in a quarry when the workmen are engaged in cutting out from the mass some immense block, intended to form a stately column or huge architrave. The eminences, like the wedges, are separated: in some places the sandstone lies between—in others there occur huge chasms filled by the sea. The Friths of Cromarty and Beauly, for instance, and the Bay of Munlochy, open into the interior between these wedge-like eminences;—the well-known Sutors of Cromarty represent two of the wedges; and it was the section furnished by the Southern Sutor that lay so immediately in the writer's neighbourhood. The line of the Cromarty Frith forms an angle of about thirty-five degrees with that of the granitic line of wedge-like hills which it bisects; and hence the peculiar shape of that tongue of land which forms the lower portion of the Black Isle, and which, washed by the Moray Frith on the one side, and by the Frith of Cromarty on the other, has its apex occupied by the Southern Sutor. Imagine a lofty promontory somewhat resembling a huge spear thrust horizontally into the sea—a ponderous mass of granitic gneiss, of about a mile in length, forming the head, and a rectilinear line of the Old Red Sandstone, more than ten miles in length, forming the shaft; and such

is the appearance which this tongue of land presents when viewed from its north-western boundary, the Cromarty Frith. When viewed from the Moray Frith —its south-western boundary—we see the same granitic spear-head, but find the line of the shaft knobbed by the other granitic eminences of the chain.

Now on this tongue of land I first broke ground as a geologist. The quarry described in my introductory chapter, as that in which my notice was first attracted by the ripple-markings, opens on the Cromarty-Frith side of this huge spear-shaft; the quarry to which I removed immediately after, and beside which I found the fossils of the Lias, opens on its Moray-Frith side. The uptilted section of sandstone occurs on both sides, where the shaft joins to the granitic spear-head, but the Lias I found on the Moray-Frith side alone. It studs the coast in detached patches, sorely worn by the incessant lashings of the Frith; and each patch bears an evident relation, in the place it occupies, to a corresponding knob or wedge in the granitic line. The Northern Sutor, as has been just said, is one of these knobs or wedges. It has its accompanying patch of Lias upheaved at its base, and lying unconformably, not only to its granitic strata, but also to it subordinate sandstones. The Southern Sutor, another of these knobs, has also its accompanying patch of Lias, which, though lying beyond the fall of the tide, strews the beach, after every storm from the east, with its shales and its fossils. The hill of Eathie is yet another knob of the series, and it, too, has it Lias patch. The granitic wedges have not only uptilted the sandstone, but they have also upheaved

the superincumbent Lias, which, but for their agency, would have remained buried under the waters of the Frith, and its ever-accumulating banks of sand and gravel. I had remarked at an early period the correspondence of the granitic knobs with the Lias patches, and striven to realize the original place and position of the latter ere the disturbing agent had upcast them to the light. What, I have asked, was the extent of this comparatively modern formation in this part of the world, ere the line of wedges were forced through from below? A wedge struck through the ice of a pond towards the centre breaks its continuity, and we find the ice on both sides the wedge; whereas, when struck through at the pond edge, it merely raises the ice from the bank, and we find it, in consequence, on but one side the wedge. Whether, have I often inquired, were the granitic wedges of this line forced through the Lias at one of its edges, or at a comparatively central point? and about ten years ago I set myself to ascertain whether I could not solve the question. The Southern Sutor is a wedge open to examination on both its sides;—the Moray Frith washes it upon one side, the Cromarty Frith on the other. Was the Lias to be found on both its sides? If so, the wedge must have been forced *through* the formation, not merely *beside* it. It occurs, as I have said, on the Moray-Frith side of the wedge; and I resolved on carefully exploring the Frith of Cromarty, to try whether it did not occur on that side too.

With this object I set out on an exploratory excursion, on a delightful morning of August 1830.

The tide was falling; it had already reached the line of half-ebb; and from the Southern Sutor to the low, long promontory on which the town of Cromarty is built, there extended a broad belt of mingled sand-banks and pools, accumulations of boulders and shingle, and large tracts darkened with algæ. I passed direct by a grassy pathway to the Sutor—the granitic spear-head of a late illustration—and turned, when I reached the curved and contorted gneiss, to trace through the broad belt left by the retiring waters, and in a line parallel to what I have described as the shaft of the huge spear, the beds and strata of the Old Red Sandstone in their ascending succession. I first crossed the conglomerate base of the system, here little more than a hundred feet in thickness. The ceaseless dash of the waves, which smooth most other rocks, has a contrary effect on this bed, except in a few localities, where its arenaceous cement or base is much indurated. Under both the Northern and Southern Sutors the softer cement yields to the incessant action; while the harder pebbles stand out in bold relief; so that wherever it presents a mural front to the breakers, we are reminded, by its appearance, of the artificial rock-work of the architect. It roughens as the rocks around it polish. Quitting the conglomerate, I next passed over a thick bed of coarse red and yellow sandstone, with here and there a few pebbles sticking from its surface, and here and there a stratum of finer-grained fissile sandstone inserted between the rougher strata; I then crossed over strata of an impure greyish limestone and a slaty clay, abounding, as I long afterwards ascertained, in

ichthyolites and vegetable remains. There are minute veins in the limestone (apparently cracks filled up) of a jet black bituminous substance, resembling anthracite; the stratified clay is mottled by layers of semi-aluminous semi-calcareous nodules, arranged like layers of flint in the upper Chalk. These nodules, when cut up and polished, present very agreeable combinations of colour; there is generally an outer ring of reddish brown, an inner ring of pale yellow, and a central patch of red, and the whole is prettily veined with dark-coloured carbonate of lime.* Passing onwards and upwards in the line of the strata, I next crossed over a series of alternate beds of coarse sandstone and stratified clay, and then lost sight of the rock altogether, in a wide waste of shingle and boulder-stones, resting on a dark blue argillaceous diluvium, sometimes employed in that part of the country, from its tenacious and impermeable character, for lining ponds and dams, and as mortar for the foundations of low-lying houses exposed in wet weather to the sudden rise of water. The numerous boulders of this tract have their story to tell, and it is a curious one. The Southern Sutor, with its multitudinous fragments of gneiss, torn from its sides by the sea, or loosened by the action of frosts and storms, and rolled down its precipices, is only a few hundred yards away:—its base, where these lie thickest, has been swept by tempests, chiefly from the east, for thousands and thousands of years; and the direct

* A concretionary limestone of the Old Red system in England, variegated with purple and green, was at one time wrought as a marble.—*Silurian System*, part i., p. 176.

effect of these tempests, regarded as transporting agents, would have been to strew this stony tract with those detached fragments. The same billow that sends its long roll from the German Ocean to sweep the base of the Sutor, and to leap up against its precipices to the height of eighty and a hundred feet, breaks in foam, only a minute after, over this stony tract; which has, in consequence, its sprinkling of fragments of gneiss transported by an agency so obvious. But for every one such fragment which it bears, we find at least ten boulders that have been borne for forty and fifty miles in the opposite direction from the interior of the country—a direction in which no transporting agency now exists. The tempests of thousands of years have conveyed for but a few hundred yards not more than a tithe of the materials of this tract; nine-tenths of the whole have been conveyed by an older agency over spaces of forty and fifty miles. How immensely more powerful, then, or how immensely protracted in its operation, must that older agency have been!

I passed onwards, and reached a little bay, or rather angular indentation of the coast, in the neighbourhood of the town. It was laid bare by the tide this morning far beyond its outer opening; and the huge table-like boulder, which occupies nearly its centre, and to which, in a former chapter, I have had occasion to refer, held but a middle place between the still darkened flood-line that ran high along the beach, and the brown line of ebb that bristled far below with forests of the rough-stemmed tangle. This little bay or inflection of the coast serves as a sort of natural

wear in detaining floating drift-weed, and is often found piled, after violent storms from the east, with accumulations, many yards in extent and several feet in depth, of kelp and tangle, mixed with zoophytes and mollusca, and the remains of fish killed among the shallows by the tempest. Early in the last century, a large body of herrings, pursued by whales and porpoises, were stranded in it, to the amount ot several hundred barrels; and it is said that salt and cask failed the packers when but comparatively a small portion of the shoal were cured, and that by much the greatest part of them were carried away by the neighbouring farmers for manure. Ever since the formation of the present coast-line, this natural wear has been arresting, tide after tide, its heaps of organic matter, but the circumstances favourable to their preservation have been wanting: they ferment and decay when driven high on the beach; and the next spring-tide, accompanied by a gale from the west, sweeps every vestige of them away; and so, after the lapse of many centuries, we find no other organisms among the rounded pebbles that form the beach of this little bay, than merely a few broken shells, and occasionally a mouldering fish-bone. Thus very barren formations may belong to periods singularly rich in organic existences. When what is now the little bay was the bottom of a profound ocean, and far from any shore, the circumstances for the preservation of its organisms must have been much more favourable. In no locality in the Old Red Sandstone with which I am acquainted, have such beautifully-preserved fossils been found. But I anticipate.

In the middle of the little bay, and throughout the greater part of its area, I found the rock exposed—a circumstance which I had marked many years before when a mere boy, without afterwards recurring to it as one of interest. But I had now learned to look at rocks with another eye; and the thought which first suggested itself to me regarding the rock of the little bay was, that I had found the especial object of my search—the Lias. The appearances are in some respects not dissimilar. The Lias of the north of Scotland is represented in some localities by dark-coloured unctuous clays, in others by greyish black sandstones that look like indurated mud, and in others by beds of black fissile shale, alternating with bands of coarse impure limestone, and studded between the bands with limestone nodules of richer quality and finer grain. The rock laid bare in the little bay is a stratified clay, of a grey colour tinged with olive, and occurring in beds separated by indurated bands of grey micaceous sandstone. They also abound in calcareous nodules. The dip of the strata, too, is very different from that of the beds which lean against the gneiss of the Sutor. Instead of an angle of eighty, it presents an angle of less than eight. The rocks of the little bay must have lain beyond the disturbing uptilting influence of the granitic wedge. So thickly are the nodules spread over the surface of some of the beds, that they reminded me of floats of broken ice on the windward side of a lake after a few days' thaw, when the edges of the fragments are smoothed and rounded, and they press upon one another, so as to cover, except in the angular interstices, the entire surface.

I set myself carefully to examine. The first nodule I laid open contained a bituminous-looking mass, in which I could trace a few pointed bones and a few minute scales. The next abounded in rhomboidal and finely-enamelled scales of much larger size and more distinct character. I wrought on with the eagerness of a discoverer entering for the first time in a *terra incognita* of wonders. Almost every fragment of clay, every splinter of sandstone, every limestone nodule, contained its organism—scales, spines, plates, bones, entire fish; but not one organism of the Lias could I find—no ammonites, no belemnites, no gryphites, no shells of any kind: the vegetable impressions were entirely different; and not a single scale, plate, or ichthyodorulite could I identify with those of the newer formation. I had got into a different world, and among the remains of a different creation; but where was its proper place in the scale? The beds of the little bay are encircled by thick accumulations of diluvium and debris, nor could I trace their relation to a single known rock. I was struck, as I well might, by the utter strangeness of the forms—the oar-like arms of the *Pterichthys* and its tortoise-like plates—the strange buckler-looking head of the *Coccosteus*, which, I suppose, might possibly be the back of a small tortoise, though the tubercles reminded me rather of the skin of the shark—the polished scales and plates of the *Osteolepis*—the spined and scaled fins of the *Cheiracanthus*—above all, the one-sided tail of at least eight out of the ten or twelve varieties of fossil which the deposit contained. All together excited and astonished me. But some time

elapsed ere I learned to distinguish the nicer generic differences of the various organisms of the formation. I found fragments of the *Pterichthys* on this morning; but I date its discovery in relation to the mind of the discoverer, more than a twelvemonth later.* I confounded the *Cheiracanthus*, too, with its single-spined membranous dorsal, with *Diplacanthus ichyolite*, furnished with two such dorsals; and the *Diplopterus* with the *Osteolepis*. Still, however, I saw enough to exhilarate and interest; I wrought on till the advancing tide came splashing over the nodules, and a powerful August sun had risen towards the middle sky; and were I to sum up all my happier hours, the hour would not be forgotten in which I sat down on a rounded boulder of granite, by the edge of the sea, when the last bed was covered, and spread out on the beach before me the spoils of the morning.

* I find, by some notes which had escaped my notice when drawing up for the *Witnsss* newspaper the sketches now expanding into a volume, that in the year 1834 I furnished the collection of a geological friend, the Rev. John Swanson, minister of the parish of Small Isles in the Outer Hebrides, with a well-marked specimen of the *Pterchthys Milleri.* The circumstance pleasingly reminds me of the first of all my early acquaintance, who learned to deem the time not idly squandered that was spent in exploring the wonders of by-gone creations. Does the minister of Small Isles still remember the boy who led him in quest of petrifactions—himself a little boy at the time—to a deep solitary cave on the Moray Frith, where they lingered amidst stalactites and mosses till the wild sea had surrounded them unmarked, barring all chance of retreat, and the dark night came on?

CHAPTER VII.

Further Discoveries of the Ichthyolite Beds—Found in one Locality under a Bed of Peat—Discovered in another beneath an ancient Burying-ground—In a third underlying the Lias formation—In a fourth overtopped by a still older Sandstone Deposit—Difficulties in ascertaining the true Place of a newly-discovered Formation—Caution against drawing too hasty Inferences from the mere circumstance of Neighbourhood—The Writer receives his first Assistance from without—*Geological Appendix* of the Messrs. Anderson of Inverness—Further Assistance from the Researches of Agassiz—Suggestion—Dr. John Malcolmson—His Extensive Discoveries in Moray—He submits to Agassiz a Drawing of the *Pterichthys*—Place of the Ichthyolites in the Scale at length determined—Two distinct Platforms of Being in the Formation to which they belong.

I COMMENCED forming a small collection, and set myself carefully to examine the neighbouring rocks for organisms of a similar character. The eye becomes practised in such researches, and my labours were soon repaid. Directly above the little bay there is a corn-field, and beyond the field a wood of forest trees; and in this wood, in the bottom of a water-course, scooped out of the rock through a bed of peat, I found the stratified clay charged with scales. A few hundred yards farther to the west there is a deep wooded ravine cut through a thick bed of red diluvial

clay. The top of the bank directly above is occupied by the ruins of an ancient chapel, and a group of moss-grown tombstones; and in the gorge of this ravine, underlying the little field of graves by about sixty feet, I discovered a still more ancient place of sepulture—that of the ichthyolites. I explored every bank, rock, and ravine on the northern or Cromarty-Frith side of the tongue of land, with its terminal point of granitic gneiss, to which I have had such frequent occasion to refer, and then turned to explore the southern or Moray-Frith side, in the rectilinear line of the great valley. And here I was successful on a larger scale. A range of lofty sandstone cliffs, hollowed by the sea, extends for a distance of about two miles between two of the granitic knobs or wedges of the line—the Southern Sutor and the hill of Eathie. And along well-nigh the entire length of this range of cliffs I succeeded in tracing a continuous ichthyolite bed, abounding in remains, and lying far below the Lias, and unconformable to it. I pursued my researches, and in the sides of a romantic precipitous dell, through which the Burn of Eathie—a small mossy stream—finds its way to the Moray Frith, I again discovered the fish-beds running deep into the interior of the country, with immense strata of a pale yellow sandstone resting over them, and strata of a chocolate-red lying below. But their place in the geological scale was still to fix.

I had seen enough to convince me that they form a continuous convex stratum in the sandstone spear-shaft, covering it saddlewise from side to side, dipping towards the Moray Frith on the south, and to

the Cromarty Frith on the north—that, as in a *bona fide* spear-shaft, the annual ring or layer of growth of one season is overlaid by the annual rings of succeeding seasons, and underlaid by those of preceding ones; so this huge semi-ring of fossiliferous clays and limestones had its underlying semi-ring of Red Sandstone, and its overlying semi-rings of yellow, of red, and of grey sandstone. I knew, besides, that beneath there was a semi-ring of conglomerate, the base of the system; and that for more than two hundred yards upwards, ring followed ring in unbroken succession—now sandstone, now limestone, now stratified clay. But though intimately acquainted with these lower rocks for more than a hundred fathoms from their base upwards, and with the upper rocks on both sides the ichthyolite bed for more than a hundred feet, there was an intervening hiatus, whose extent at this period I found it impossible to ascertain. And hence my uncertainty regarding the place of the ichthyolites, seeing that whole formations might be represented by the occurring gap. On the Moray-Frith side, where the sections are of huge extent, a doubtful repeat in the strata at one point of junction, and an abrupt fault at another, cuts off the upper series of beds to which the organisms belong, from the lower to which the great conglomerate belongs. On the Cromarty-Frith side the sections are mere detached patches, obscured at every point by diluvium and soil; and, in conceiving of the whole as a continuous line, with the Lias atop and the granite group at the bottom, I was ever reminded of those coast-lines of the ancient geographers, where a few uncertain

dots, a few deeper markings, and here and there a blank space or two, showed the blended results of conjecture and discovery—whether they give a *Terra Incognita Australia* to the one hemisphere, or a North-Western passage to the other. The ichthyolites in a section so doubtful might be regarded as belonging to either the Old or the New Red Sandstone—to the Coal Measures or to the Mountain Limestone. All was uncertainty.

One remark in the passing: it may teach the young geologist to be cautious in his inferences, and illustrate, besides, those gaps which occur in the geological scale. I had now discovered the ichthyolite beds in five different localities; in one of these—the first discovered—there is no overlying stratum; it seems as if the bed formed the top of the formation: in all the others the overlying stratum is different, and belongs to distant and widely-separated ages. We cut in one locality through a peat-moss—part of the ruins, perhaps, of one of those forests which covered, about the commencement of the Christian era, well-nigh the entire surface of the island, and sheltered the naked inhabitants from the legions of Agricola. We find, as we dig, huge trunks of oak and elm, cones of the Scotch fir, handfuls of hazel-nuts, and bones and horns of the roe and the red-deer. The writer, when a boy, found among the peat the horn of a gigantic elk. And, forming the bottom of this recent deposit, and *lying conformably to it*, we find the ichthyolite beds, with their antique organisms. The remains of oak and elm leaves, and of the spikes and cones of the pine, lie within half a foot of the remains of the

Coccosteus and *Diplopterus*. We dig in another locality through an ancient burying-ground; we pass through a superior stratum of skulls and coffins, and an inferior stratum barren in organic remains, and then arrive at the stratified clays, with their ichthyolites. In a third locality we find these in junction with the Lias, and underlying its lignites, ammonites, and belemnites, just as we see them underlying, in the other two, the human bones and the peat-moss. And in yet a fourth locality we see them overlaid by immense arenaceous beds, that belong evidently, as their mineralogical character testifies, to either the Old or the New Red Sandstone. The convulsions and revolutions of the geological world, like those of the political, are sad confounders of place and station, and bring into close fellowship the high and the low; nor is it safe in either world—such have been the effects of the disturbing agencies—to judge of ancient relations by existing neighbourhoods, or of original situations by present places of occupancy. "Misery," says Shakspeare, "makes strange bed-fellows." The changes and convulsions of the geological world have made strange bed-fellows too. I have seen fossils of the Upper Lias and of the Lower Old Red Sandstone washed together by the same wave, out of what might be taken, on a cursory survey, for the same bed, and then mingled with recent shells, algæ, branches of trees, and fragments of wrecks on the same sea-beach.

Years passed, and in 1834 I received my first assistance from without, through the kindness of the Messrs. Anderson of Inverness, who this year pub-

lished their *Guide to the Highlands and Islands of Scotland*—a work which has never received half its due measure of praise. It contains, in a condensed and very pleasing form, the accumulated gleanings, for half a lifetime, of two very superior men, skilled in science, and of highly cultivated taste and literary ability; whose remarks from their intimate acquaintance with every foot-breadth of country which they describe, invariably exhibit that freshness of actual observation, recorded on the spot, which Gray regarded as "worth whole cart-loads of recollection." But what chiefly interested me in their work was its dissertative appendices—admirable digests of the Natural History, Antiquities, and Geology of the country. The appendix devoted to Geology, consisting of fifty closely-printed pages—abridged in part from the highest geological authorities, and in much greater part the result of original observation—contains beyond comparison the completest description of the rocks, fossils, and formations of the Northern and Western Highlands, which has yet been given to the public in a popular form. I perused it with intense interest, and learned from it, for the first time, of the fossil fishes of Caithness and Gamrie.

There was almost nothing known at the period, of the oryctology of the older rocks—little, indeed, of that of the Old Red Sandstone, in its proper character as such; and, with no such guiding clue as has since been furnished by Agassiz, and the later researches of Mr. Murchison, the writer of the appendix had recorded as his ultimate conclusion, that "the middle schistoze system of Caithness, containing the

fossil fish, was intermediate in geological character and position between the Old and New Red Sandstone formations." The ichthyolites of Gamrie he described as resembling those of Caithness; and I at once recognised, in his minute descriptions of both, the fossil fish of Cromarty. The mineralogical accompaniments, too, seemed nearly the same. In Caithness the animal remains are mixed up in some places with a black bituminous matter like tar. I had but lately found among the beds of the little bay a mass of soft adhesive bitumen, hermetically sealed up in the limestone, which, when broken open, reminded me, from the powerful odour it cast, and which filled for several days the room in which I kept it, of the old Gaulish mummy of which we find so minute account in the Natural History of Goldsmith. The nodules which enclosed the organisms at Gamrie were described as of a sub-crystalline, radiating, fibrous structure. So much was this the case with some of the nodules at Cromarty, that they had often reminded me, when freshly broken, though composed of pure carbonate of lime, of masses of asbestos. The scales and bones of the Caithness ichthyolites were blended, it was stated, with the fragments of a "supposed tortoise nearly allied to trionyx;" one of the ichthyolites, a *Dipterus*, was characterized by large scales, a double dorsal, and a one-sided tail; the entire lack of shells and zoophytes was remarked, and the abundance of obscure vegetable impressions. In short, had the accomplished writer of the appendix been briefly describing the beds at Cromarty, instead of those of Caithness and Gamrie, he might have

employed the same terms, and remarked the same circumstances—the striated nodules, the mineral tar, the vegetable impressions, the absence of shells and zoophytes, the large-scaled, and double-finned ichthyolites—the peculiarities of which applied equally to the *Dipterus* and *Diplopterus*—and the supposed tortoise, in which I once recognised the *Coccosteus.* It was much to know that this doubtful formation—for as doubtful I still regarded it—was of such considerable extent, and occurred in localities so widely separated. I corresponded with the courteous author of the appendix, at that time General Secretary to the Northern Institution for the Promotion of Science and Literature, and Conservator of its Museum; and, forwarding to him duplicates of some of my better specimens, had, as I had anticipated, the generic identity of the Cromarty ichthyolites with those of Caithness and Gamrie fully confirmed.

My narrative is, I am afraid, becoming tedious; but it embodies somewhat more than the mere history of a sort of Robinson Crusoe in Geology, cut off for years from all intercourse with his kind. It contains also the history of a formation in its connection with science; and the reader will, I trust, bear with me for a few pages more. Seasons passed; and I received new light from the researches of Agassiz, which, if it did not show me my way more clearly, rendered it at least more interesting, by associating with it one of those wonderful truths, stranger than fictions, which rise ever and anon from the profounder depths of science, and whose use, in their connection with the human intellect, seems to be to stimulate the faculties.

I have often had occasion to refer to the one-sided condition of tail characteristic of the ichthyolites of the Old Red Sandstone. It characterizes, says Agassiz, the fish of all the more ancient formations. At one certain point in the descending scale Nature entirely alters her plan in the formation of the tail. All the ichthyolites above are fashioned after one particular type—all below after another and different type. The bibliographer can tell at what periods in the history of letters one character ceased to be employed and another came into use. Black letter, for instance, in our own country, was scarce ever resorted to for purposes of general literature after the reign of James VI.; and in manuscript writing the Italian hand superseded the Saxon about the close of the seventeenth century. Now, is it not truly wonderful to find an analogous change of character in that pictorial history of the past which Geology furnishes? From the first appearance of vertebrated existences to the middle beds of the New Red Sandstone—a space including the Upper Ludlow rocks, the Old Red Sandstone in all its members, the Mountain Limestone, with the Limestone of Burdie House, the Coal Measures, the Lower New Red, and the Magnesian Limestone—we find only the ancient or unequally-lobed type of tail. In all the formations above, including the Lias, the Oolite, Middle, Upper, and Lower, the Wealden, the Green-sand, the Chalk, and the Tertiary, we find only the equally-lobed condition of tail. And it is more than probable, that with the tail the character of the skeleton also changed; that the more ancient type characterized, throughout,

the semi-cartilaginous order of fishes, just as the more modern type characterizes the osseous fishes; and that the upper line of the Magnesian Limestone marks the period at which the order became extinct. Conjecture lacks footing in grappling with a revolution so extensive and so wonderful. Shall I venture to throw out a suggestion on the subject, in connection with another suggestion which has emanated from one of the first of living geologists? Fish, of all existing creatures, seem the most capable of sustaining high degrees of heat, and are to be found in some of the hot springs of Continental Europe, where it is supposed scarce any other animal could live. Now, all the fish of the ancient type are thickly covered by a defensive armour of bone, arranged in plates, bars, or scales, or all the three modes together, as in the *Osteolepis* and one-half its cotemporaries. The one-sided tail is united invariably to a strong cuirass. And it has been suggested by Dr. Buckland, that this strong cuirass may have formed a sort of defence against the injurious effects of a highly heated surrounding medium. The suggestion is, of course, based purely on hypothesis. It may be stated in direct connection with it, however, that in the Lias—the first richly fossiliferous formation overlying that in which the change occurred—we find, for the first time in the geological system, decided indications of a change of seasons. The foot-prints of winter are left impressed amid the lignites of the Cromarty Lias. In a specimen now before me, the alternations of summer-heat and winter-cold are as distinctly marked in the annual rings, as in the pines or larches of our present forests;

whereas in the earlier lignites, cotemporary with ichthyolites of the ancient type, either no annual rings appear, or the markings, if present, are both faint and unfrequent. *Just ere winter began to take its place among the seasons, the fish fitted for living in a highly heated medium disappeared:* they were created to inhabit a thermal ocean, and died away as it cooled down. Fish of a similar type may now inhabit the seas of Venus, or even of Jupiter, which, from its enormous bulk, though greatly more distant from the sun than our earth, may still powerfully retain the internal heat.

I still pursued my inquiries, and received a valuable auxiliary in a gentleman from India, Dr. John Malcolmson of Madras—a member of the London Geological Society, and a man of high scientific attainments and great general knowledge. Above all, I found him to possess, in a remarkable degree, that spirit of research, almost amounting to a passion, which invariably marks the superior man. He had spent month after month under the burning sun of India, amid fever-marshes and tiger-jungles, acquainting himself with the unexplored geological field which, only a few years ago, that vast continent presented, and in collecting fossils hitherto unnamed and undescribed. He had pursued his inquiries, too, along the coasts of the Red Sea, and far upwards on the banks of the Nile; and now, in returning for a time to his own country, he had brought with him the determination of knowing it thoroughly as a man of science and a geologist. I had the pleasure of first introducing him to the ichthyolites of the Lower Old Red

Sandstone, by bringing him to my first-discovered bed, and laying open, by a blow of the hammer, a beautiful *Osteolepis.* He was much interested in the fossils of my little collection, and at once decided that the formation which contained them could be no representative of the Coal Measures. After ranging over the various beds on both sides the rectilinear ridge, and acquainting himself thoroughly with their organisms, he set out to explore the Lower Old Red Sandstones of Moray and Banff, hitherto deemed peculiarly barren, but whose character too much resembled that of the rocks which he had now ascertained to be so abundant in fossils, not to be held worthy of further examination. He explored the banks of the Spey, and found the ichthyolite beds extensively developed at Dipple, in the middle of an Old Red Sandstone district. He pursued his researches, and traced the formation in ravines and the beds of rivers, from the village of Buckie to near the field of Culloden; he found it exposed in the banks of the Nairn, in the ravines above Cawdor Castle, on the eastern side of the hill of Rait, at Clune, Lethenbar, and in the vale of Rothes—and in every instance low in the Old Red Sandstone. The formation hitherto deemed so barren in remains proved one of the richest of them all, if not in tribes and families, at least in individual fossils; and the reader may form some idea of the extent in which it has already been proved fossiliferous, when he remembers that the tract includes as its extremes, Orkney, Gamrie, and the north-eastern gorge of the great Caledonian Valley. The ichthyolites were discovered in the latter locality in the quarry

of Inches, three miles beyond Inverness, by Mr. George Anderson, the gentleman to whose geological attainments, as one of the authors of the *Guide Book*, I have lately had occasion to refer.

I had now corresponded for several years with a little circle of geological friends, and had described in my letters, and in some instances had attempted to figure in them, my newly-found fossils. A letter which I wrote early in 1838 to Dr. Malcolmson, then at Paris, and which contained a rude drawing of the *Pterichthys*, was submitted to Agassiz, and the curiosity of the naturalist was excited. He examined the figure, rather, however, with interest than surprise, and read the accompanying description, not in the least inclined to scepticism by the singularity of its details. He had looked on too many wonders of a similar cast to believe that he had exhausted them, or to evince any astonishment that Geology should be found to contain one wonder more. Some months after I sent a restored drawing of the same fossil to the Elgin Scientific Society. I must state, however, that the restoration was by no means complete. The paddle-like arms were placed further below the shoulders than in any actual species; and I had transferred, by mistake, to the creature's upper side some of the plates of the *Coccosteus*. Still the type was unequivocally that of the *Pterichthys*. The secretary of the Society, Mr. Patrick Duff, an excellent geologist, to whose labours, in an upper formation of the Old Red Sandstone, I shall have afterwards occasion to refer, questioned, as he well might, some of the details of the figure, and we corresponded for several weeks re-

garding it, somewhat in the style of Jonathan Oldbuck and his antiquarian friend, who succeeded in settling the meaning of two whole words, in an antique inscription, in little more than two years. Most of the other members looked upon the entire drawing, so strange did the appearance seem, as embodying a fiction of the same class with those embodied in the pictured griffins and unicorns of mythologic Zoology; and, in amusing themselves with it, they bestowed on its betailed and bepaddled figure, as if in anticipation of Agassiz, the name of the draughtsman. Not many months after, however, a *bona fide Pterichthys* turned up in one of the newly-discovered beds of Nairnshire, and the Association ceased to joke, and began to wonder. I merely mention the circumstance in connection with a right challenged, at the late meeting of the British Association at Glasgow, by a gentleman of Elgin, to be regarded as the original discoverer of the *Pterichthys*. I am of course far from supposing that the discovery was not actually made, but regret that it should have been kept so close a secret at a time when it might have stood the other discoverer of the creature in such stead.

The exact place of the ichthyolites in the system was still to fix. I was spending a day early in the winter of 1839 among the nearly vertical strata that lean against the Northern Sutor. The section there presented is washed by the tide for nearly three hundred yards from where it rests on the granitic gneiss; and each succeeding stratum in the ascending order may be as clearly traced as the alternate white and black squares in a marble pavement. First there is

a bed of conglomerate two hundred and fifteen feet in thickness, "identical in structure," says Professor Sedgwick and Mr. Murchison, "with the older red conglomerates of Cumberland and the Island of Arran,* and which cannot be distinguished from those conglomerates which lean against the southern flank of the Grampians, and on which Dunnottar Castle is built. Immediately above the conglomerate there is a hundred and fourteen feet more of coarse sandstone strata, of a reddish-yellow hue, with occasionally a few pebbles enclosed, and then twenty-seven feet additional of limestone and stratified clay. There are no breaks, no faults, no thinning out of strata—all the beds lie parallel, showing regular deposition. I had passed over the section twenty times before, and had carefully examined the limestone and the clay, but in vain. On this occasion, however, I was more fortunate. I struck off a fragment. It contained a vegetable impression of the same character with those of the ichthyolite beds; and after an hour's diligent search, I had turned from out the heart of the stratum plates and scales enough to fill a shelf in a museum—the helmet-like snout of an *Osteolepis*, the thorn-like spine of a *Cheiracanthus*, and a *Coccosteus* well-nigh entire. I had at length, after a search of nearly ten years, found the true place of the ichthyolite bed. The reader may smile, but I hope the smile will be a

* Different in one respect from the conglomerates of Arran. It abounds in rolled fragments of granite, whereas in those of Arran there occur no pebbles of this rock. Arran has now its granite in abundance; the northern locality has none; though, when the conglomerates of the Lower Old Red Sandstone were in the course of forming, the case was exactly the reverse.

good-natured one; a simple pleasure may be not the less sincere on account of its simplicity; and "little things are great to little men." I passed over and over the strata, and found there could be no mistake. The place of the fossil fish in the scale is little more than a hundred feet above the top, and not much more than a hundred yards above the base of the great conglomerate; and there lie over it in this section about five hundred feet of soft arenaceous stone, with here and there alternating bands of limestone and beds of clay studded with nodules—all belonging to the inferior Old Red Sandstone.

The enormous depth of the Old Red Sandstone of England has been divided by Mr. Murchison into three members or formations—the division adopted in his *Elements* by Mr. Lyell, as quoted in an early chapter. These are, the lowest or Tilestone formation, the middle or Cornstone formation, and the uppermost or Quartzose-conglomerate formation. The terms are derived from mineralogical character, and inadequate as designations, therefore, like that of the Old Red Sandstone itself, which in many of its deposits is not *sandstone*, and is not *red*. But they serve to express great natural divisions. Now the Tilestone member of England represents, as I have already stated, this Lower Old Red Sandstone formation of Scotland; but its extent of vertical development, compared with that of the other two members of the system, is strikingly different in the two countries. The Tilestones compose the least of the three divisions in England;—their representative in Scotland forms by much the greatest of the three; and there seems to be

zoological as well as lithological evidence that its formation must have occupied no brief period. *The same genera occur in its upper as in its lower beds, but the species appear to be different.* I shall briefly state the evidence of this very curious fact.

The seat of Sir William Gordon Cumming of Altyre is in the neighbourhood of one of the Morayshire deposits discovered by Mr. Malcolmson; and for the greater part of the last two years Lady Gordon Cumming has been engaged in making a collection of its peculiar fossils, which already fills an entire apartment. The object of her Ladyship was the illustration of the Geology of the district, and all she sought in it on her own behalf was congenial employment for a singularly elegant and comprehensive mind. But her labours have rendered her a benefactor to science. Her collection was visited, shortly after the late meeting of the British Association in Glasgow, by Agassiz and Dr. Buckland: and great was the surprise and delight of the philosophers to find that the whole was new to Geology. All the species, amounting to eleven, and at least one of the genera, that of the *Glyptolepis*, were different from any Agassiz had ever seen or described before. The deposit so successfully explored by her Ladyship occurs high in the lower formation. Agassiz, shortly after, in comparing the collection of Dr. Traill, (a collection formed at Orkney) with that of the writer (a collection made at Cromarty) was struck by the specific identity of the specimens. In the instances in which the genera agreed he found that the species agreed also, though the ichthyolites of both

differed specifically from the ichthyolites of Caithness, which occur chiefly in the upper beds of the formation, and from those also of Lady Cumming of Altyre, which occur, as I have said, at the top. And in examining into the cause, it was found that the two collections, though furnished by localities more than a hundred miles apart, were yet derived, if I may so express myself, from the same low platform, both alike representing the fossiliferous base of the system, and both removed but by a single stage from the great unfossiliferous conglomerate below. Thus there seem to be what may be termed two storeys of being in this lower formation—storeys in which the groups, though generically identical, are specifically dissimilar.*

* Since this period, however, several species identical with those of Cromarty have been found in the Morayshire deposits.

CHAPTER VIII.

Upper Formations of the Old Red Sandstone—Room enough for each and to spare—Middle or Cornstone Formation—The *Cephalaspis* its most characteristic Organism—Description—The Den of Balruddery richer in the Fossils of this middle Formation than any other Locality yet discovered—Various Cotemporaries of the *Cephalaspis*—Vegetable Impressions—Gigantic Crustacean—*Seraphim*—Ichthyodorulites—Sketch of the Geology of Forfarshire—Its older Deposits of the Cornstone Formation—The Quarries of Carmylie—Their Vegetable and Animal Remains—the Upper Formation—Wide Extent of the Fauna and Flora of the earlier Formations—Probable Cause.

Hitherto I have dwelt almost exclusively on the fossils of the Lower Old Red Sandstone, and the history of their discovery: I shall now ascend to the organisms of its higher platforms. The system in Scotland, as in the sister kingdom, has its middle and upper groups, and these are in no degree less curious than the inferior group already described, nor do they more resemble the existences of the present time. Does the reader remember the illustration of the pyramid employed in an early chapter—its three parallel bars, and the strange hieroglyphics of the middle bar? Let him now imagine another pyramid, inscribed with the remaining and later history of the system. We read, as before, from the base upwards, but find the broken and half-defaced characters of the second

erection descending into the very soil, as in those obelisks of Egypt round which the sands of the desert have been accumulating for ages. Hence a hiatus in our history for future excavators to fill; and it contains many such blanks, every unfossiliferous bar in either pyramid representing a gap in the record. Three distinct formations the group undoubtedly contains—perhaps more; nor will the fact appear strange to the reader who remembers how numerous the formations are that lie over and under it, and that its vast depth of ten thousand feet equals that of the whole secondary system from top to bottom. Eight such formations as the Oolite, or ten such formations as the Chalk, could rest, the one over the other, in the space occupied by a group so enormous. To the evidence of its three distinct formations, which is of a very simple character, I shall advert as I go along.

The central or Cornstone division of the system in England is characterized throughout its vast depth by a peculiar family of ichthyolites, which occur in none of the other divisions. I have already had occasion to refer to the *Cephalaspis*. Four species of this fish have been discovered in the Cornstones of Hereford, Salop, Worcester, Monmouth, and Brecon;* "and as they are always found," says Mr. Murchison, "in the same division of the Old Red System, they have become valuable auxiliaries in enabling the geologist to identify its subdivisions through England and Wales, and also to institute direct comparisons between the different strata of the Old Red Sandstone of England and Scotland." The *Cephalaspis* is one of the most

* *Cephalaspis Lewisii*, *C. Lloydii*, *C. Lyellii*, and *C. rostratus.*

curious ichthyolites of the system. (See Plate X., fig. 1.) Has the reader ever seen a saddler's cutting knife?—a tool with a crescent-shaped blade, and the handle fixed transversely in the centre of its concave side. In general outline the *Cephalaspis* resembled this tool—the crescent-shaped blade representing the head—the transverse handle the body. We have but to give the handle an angular instead of a rounded shape, and to press together the pointed horns of the crescent till they incline towards each other, and the convex or sharpened edge is elongated into a semi-ellipse, cut in the line of its shortest diameter, in order to produce the complete form of the *Cephalaspis.* The head, compared with the body, was of great size —comprising fully one-third the creature's entire length. In the centre, and placed closely together, as in many of the flat fish, were the eyes. Some of the specimens show two dorsals, and an anal and caudal fin. The thin and angular body presents a jointed appearance, somewhat like that of a lobster or trilobite. Like the bodies of most of the ichthyolites of the system, it was covered with variously-formed scales of bone; the creature's head was cased in strong plates of the same material, the whole upper side lying under one huge buckler—and hence the name *Cephalaspis*, or buckler-head. In proportion to its strength and size, it seems to have been amply furnished with weapons of defence. Such was the strength and massiveness of its covering, that its remains are found comparatively entire in arenaceous rocks impregnated with iron, in which few other fossils could have survived. Its various species, as they

occur in the Welsh and English Cornstones, says Mr. Murchison, seem "not to have been suddenly killed and entombed, but to have been long exposed to submarine agencies, such as the attacks of animals, currents, concretionary action," &c.; and yet, "though much dismembered, the geologist has little difficulty in recognising even the smallest portions of them." Nor does it seem to have been quite unfurnished with offensive weapons. The sword-fish, with its strong and pointed spear, has been known to perforate the oaken ribs of the firmest-built vessels; and, poised and directed by its lesser fins, and impelled by its powerful tail, it may be regarded either as an arrow or javelin flung with tremendous force, or as a knight speeding to the encounter with his lance in rest. Now there are missiles employed in Eastern warfare, which, instead of being pointed like the arrow or javelin, are edged somewhat like the crooked falchion or saddler's cutting-knife, and which are capable of being cast with such force, that they have been known to sever a horse's leg through the bone; and if the sword-fish may be properly compared to an arrow or javelin, the combative powers of the *Cephalaspis* may be illustrated, it is probable, by a weapon of this kind—the head all around its elliptical margin presenting a sharp edge, like that of a cutting-knife or falchion. Its impetus, however, must have been comparatively small, for its organs of motion were so: it was a bolt carefully fashioned, but a bolt cast from a feeble bow. But if weak in the assault, it must have been formidable when assailed. "The pointed horns of the crescent," said Agassiz to the writer, "seem to have

served a similar purpose with the spear-like wings of the *Pterichthys*"—the sole difference consisting in the circumstance, that the spears of the one could be elevated or depressed at pleasure, whereas those of the other were ever fixed in the warlike attitude. And such was the *Cephalaspis* of the Cornstones—not only the most characteristic, but in England and Wales almost the sole organism of the formation.

Now of this curious ichthyolite we find no trace among the fossils of the Lower Old Red Sandstone. It occurs neither in Orkney nor Cromarty, Caithness nor Gamrie, Nairnshire nor the inferior ichthyolite beds of Moray. Neither in England nor in Scotland is it to be found in the Tilestone formation, or its equivalent. It is common, however, in the Old Red Sandstone of Forfarshire; and it occurs at Balruddery, in the Grey Sandstones which form on both sides the Tay, where the Tilestone formation seems wanting, the apparent base of the system. It is exclusively a medal of the middle empire.

In the last-mentioned locality, in a beautifully-wooded dell, known as the Den of Balruddery, the *Cephalaspis* is found associated with an entire group of other fossils, the recent discovery of Mr. Webster, the proprietor, who, with a zeal through which geological knowledge promises to be materially extended, and at an expense of much labour, has made a collection of all the organisms of the Den yet discovered. These the writer had the pleasure of examining in the company of Mr. Murchison and Dr. Buckland: he was afterwards present when they were examined by Agassiz; and not a single organism of the group

could be identified on either occasion, by any member of the party, with those of the lower or upper formations. Even the genera are dissimilar. The fossils of the Lias scarce differ more from those of the Coal Measures, than the fossils of the Middle Old Red Sandstone from the fossils of the formations that rest over and under them. Each formation has its distinct group—a fact so important to the geologist, that he may feel an interest in its further verification through the decision of yet another high authority. The superior Old Red Sandstones of Scotland were first ascertained to be fossiliferous by Professor Fleming of King's College, Aberdeen,* confessedly one of the

* The Upper Old Red Sandstones of Moray were ascertained to be fossiliferous at nearly the same time by Mr. Martin of the Anderson Institution, Elgin. There is a mouldering conglomerate precipice termed the *Scat-Craig*, about four miles to the south of the town, more abundant in remains than perhaps any of the other deposits of the formation yet discovered; and in this precipice Mr. Martin first commenced his labours in the Red Sandstone of the district, and found it a mine of wonders. It is a place of singular interest—a rock of sepulchres; and its teeth, scales, and single bones occur in a state of great entireness; though, ere the deposit was formed, the various ichthyolites whose remains it contains seem to have been broken up, and their fragments scattered. Accumulations of larger and smaller pebbles alternate in the strata; and the bulkier bones and teeth are found invariably among the bulkier pebbles, thus showing that they were operated upon by the same laws of motion which operated on the inorganic contents of the deposit. At a considerably later period the fossils of the upper group were detected in the precipitous and romantic banks of the Findhorn, by Dr. Malcolmson of Madras, when prosecuting his discoveries of the organisms of the lower formation. He found them also, though in less abundance, in a splendid section exhibited in the Burn of Lethen, a rivulet of Moray, and yet again in the neighbourhood of Altyre. The Rev. Mr. Gordon of Birnie, and Mr. Robertson of Inverugie, have been also discoverers

first naturalists of the age, and who, to his minute acquaintance with existing forms of being, adds an acquaintance scarcely less minute with those forms of primeval life that no longer exist. He it was who first discovered, in the Upper Old Red Sandstones

in the district. To the geological labours of Mr. Patrick Duff of Elgin, in the same field, I have already had occasion incidentall to refer. The patient inquiries of this gentleman have been prosecuted for years in all the formations of the province, from the Weald of Linksfield, with its peculiar lacustrine remains—lignites, minute fresh-water shells and the teeth, spines, and vertebræ of fish and saurians—down to the base of the Old Red Sandstone, with its *Coccostei*, *Dipteri*, and *Pterichthyes*. His acquaintance with the organisms of the *Scat-Craig* is at once more extensive and minute than that of perhaps any other geologist; and his collection of them very valuable, representing, as it does, a formation of much interest, still little known. Mr. Duff is at present engaged on a volume descriptive of the Geology of the province of Moray, a district extensively explored of late years, and abundant in its distinct groups of organisms, but of which general readers have still much to learn; and from no one could they learn more regarding it than from Mr. Duff. It is still only a few months since the Upper Old Red Sandstones of the southern districts of Scotland were found to be fossiliferous; and the writer is chiefly indebted for his acquaintance with their organisms to a tradesman of Berwickshire, Mr. William Stevenson of Dunse, who, on perusing some of the geological articles which appeared in the *Witness* newspaper, during the course of the last autumn, sent him a parcel of fossils disinterred from out the deep belt of Red Sandstone which leans, to the south in that locality, against the grauwacke of the Lammermuirs. Mr. Stevenson had recently discovered them, he stated, near Preston-haugh, about two miles north of Dunse, in a fine section of alternating Sandstone and conglomerate strata that lie unconformably on the grauwacke. They consist of scales and occipital plates of the *Holoptychius*, with the remains of a bulky but very imperfectly-preserved ichthyodorulite; and the coarse arenaceous matrices which surround them seem identical with the red gritty Sandstones of the Findhorn and the *Scat-Craig*.

of Fifeshire, the large scales and plates of that strikingly characteristic ichthyolite of the higher formation, now known as the *Holoptychius*—of which more anon; and, unquestionably, no one acquainted with his writings, or the character of his mind, can doubt that he examined carefully. Now, a few years since, I had the pleasure of introducing Professor Fleming to the organisms of the Lower Old Red Sandstone, as they occur in the neighbourhood of Cromarty; and, notwithstanding his extensive acquaintance with the upper fossils of the system, he found himself, among the lower, in an entirely new field. His knowledge of the one group served but to show him how very different it was from the other. With the organisms of the lower he minutely acquainted himself: he collected specimens from Gamrie, Caithness, and Cromarty, and studied their peculiarities; and yet, on being introduced last year to the discoveries of Mr. Webster at Balruddery, he found his acquaintance with both the upper and lower groups stand him in but the same stead that his first acquired knowledge of the upper group had stood him a few years before. He agreed with Agassiz in pronouncing the group at Balruddery essentially a new group. Add to this evidence the well-weighed testimony of Mr. Murchison regarding the three formations which the Old Red Sandstone contains in England, where the entire system is found continuous, the Cornstone overlying the Tilestone, and the Quartzose conglomerate the Cornstone; take into account the fact that there, each formation has its characteristic fossil, identical with some characteristic fossil of the corresponding

formation of Scotland—that the Tilestones of the one, and the lower group of the other, have their *Dipterus* in common—that the Cornstones of the one, and the middle group of the other, have their *Cephalaspis* in common—that the Quartzose conglomerate of the one, and the upper group of the other, have their *Holoptychius* in common; and then say whether the proofs of distinct succeeding formations can be more surely established. If, however, the reader still entertain a doubt, let him consult the singularly instructive section of the entire system, from the Carboniferous Limestone to the Upper Silurian, given by Mr. Murchison in his *Silurian System* (Part II., Plate XXXI., fig. 1), and he will find the doubt vanish. But to return to the fossils of the Cornstone group.

The characteristic fossil of this deposit, the *Cephalaspis*, occurs in considerable abundance in Forfarshire, and in a much more entire state than in the Cornstones of England and Wales. The rocks to which it belongs are also developed, though more sparingly, in the northern extremity of Fife, in a line parallel to the southern shores of the Tay. But of all the localities yet known, the Den of Balruddery is that in which the peculiar organisms of the formation may be studied with best effect. The oryctology of the Cornstones of England seems restricted to four species of the *Cephalaspis*. In Fife all the organisms of the formation yet discovered are exclusively vegetable—darkened impressions of stems like those of the inferior ichthyolite beds, confusedly mixed with what seem slender and pointed leaflets drawn in black, and

numerous circular forms which have been deemed the remains of the seed vessels of some unknown subaerial plant. "These last occur," says Professor Fleming, the original discoverer, "in the form of circular flat patches, not equalling an inch in diameter, and composed of numerous smaller contiguous circular pieces;" the *tout ensemble* resembling "what might be expected to result from a compressed berry, such as the bramble or the rasp." In Forfarshire the remains of the *Cephalaspis* are found associated with impressions of a different character, though equally obscure—impressions of polished surfaces carved into seeming scales; but in Balruddery alone are the vegetable impressions of the one locality, and the scaly impressions of the other, together with the characteristic ichthyolites of England and Forfarshire, found associated with numerous fossils besides, many of them obscure, but all of them of interest, and all of them new to Geology.

One of the strangest organisms of the formation is a fossil lobster, of such huge proportions, that one of the average-sized lobsters, common in our markets, might stretch its entire length across the continuous tail-flap in which the creature terminated. And it is a marked characteristic of the fossil, that the terminal flap should be continuous; in all the existing varieties with which I am acquainted it is divided into angular sections. The claws nearly resembled those of the common lobster: their outline is similar; there is the same hawk-bill curvature outside, and the inner sides of the pincers are armed with similar teeth-like tubercles. The immense shield which covered the upper

part of the creature's body is more angular than in the existing varieties, and resembles, both in form and size, one of those lozenge-shaped shields worn by knights of the middle ages on gala days, rather for ornament than use, and on which the herald still inscribes the armorial bearing of ladies who bear title in their own right. As shown in some of the larger specimens, the length of this gigantic crustacean must have exceeded four feet. Its shelly armour was delicately fretted with the forms of circular or elliptical scales. On all the many plates of which it was composed we see these described by gracefully-waved lines, and rising apparently from under one another, row beyond row. They were, however, as much the mere semblance of scales as those relieved by the sculptor on the corslet of a warrior's effigy on a Gothic tomb—mere sculpturings on the surface of the shell. This peculiarity may be regarded as throwing light on the hitherto doubtful impressions of the sandstone of Forfarshire—impressions, as has been said, of smooth surfaces carved into seeming scales. They occur as impressions merely, the sandstone retaining no more of the original substance of the organism than the impressed wax does of the substance of the seal; and the workmen in the quarries in which they occur, finding form without body, and struck by the resemblance which the delicately-waved scales bear to the sculptured markings on the wings of cherubs—of all subjects of the chisel the most common—fancifully termed them *Seraphim*. They have turned out, as was anticipated, to be the detached plates of some such crustacean as the lobster of Balruddery.

The ability displayed by Cuvier in restoring, from a few broken fragments of bone, the skeleton of the entire animal to which the fragments had belonged, astonished the world. He had learned to interpret signs as incomprehensible to every one else as the mysterious handwriting on the wall had been to the courtiers of Belshazzar. The condyle of a jaw became in his hands a key to the character of the original possessor; and in a few mouldering vertebræ, or in the dilapidated bones of a fore arm or a foot, he could read a curious history of habits and instincts. In common with several gentlemen of Edinburgh, all men known to science, I was as much struck with the skill displayed by Agassiz in piecing together the fragments of the huge crustacean of Balruddery, and in demonstrating its nature as such. The numerous specimens of Mr. Webster were opened out before us. On a previous morning I had examined them, as I have said, in the company of Mr. Murchison and Dr. Buckland; they had been seen also by Lord Greenock, Dr. Traill, and Mr. Charles M'Laren; and their fragments of new and undescribed fishes had been at once recognised with reference to at least their class. But the collection contained organisms of a different kind, which seemed inexplicable to all—forms of various design, but so regularly mathematical in their outlines that they might be all described by a ruler and a pair of compasses, and yet the whole were covered by seeming scales. There were the fragments of scaly rhombs, of scaly crescents, of scaly circles, with scaly parallelograms attached to them, and of several other regular compound figures besides. Mr. Murchison,

familiar with the older fossils, remarked the close resemblance of the seeming scales to those of the *Seraphim* of Forfarshire, but deferred the whole to the judgment of Agassiz; no one else hazarded a conjecture. Agassiz glanced over the collection. One specimen especially caught his attention—an elegantly symmetrical one. It seemed a combination of the parallelogram and the crescent: there were pointed horns at each end; but the convex and concave lines of the opposite sides passed into almost parallel right lines toward the centre. His eye brightened as he contemplated it. "I will tell you," he said, turning to the company—"I will tell you what these are—the remains of a huge lobster." He arranged the specimens in the group before him with as much apparent ease as I have seen a young girl arranging the pieces of ivory or mother-of-pearl in an Indian puzzle. A few broken pieces completed the lozenge-shaped shield; two detached specimens placed on its opposite sides furnished the claws; two or three semi-rings with serrated edges composed the jointed body; the compound figure, which but a minute before had so strongly attracted his attention, furnished the terminal flap; and there lay the huge lobster before us, palpable to all. There is homage due to supereminent genius, which nature spontaneously pays when there are no low feelings of envy or jealousy to interfere with her operations; and the reader may well believe that it was willingly rendered on this occasion to the genius of Agassiz.

The terminal flap of this gigantic crustacean was, as I have said, continuous. The creature, however,

Fig 1.

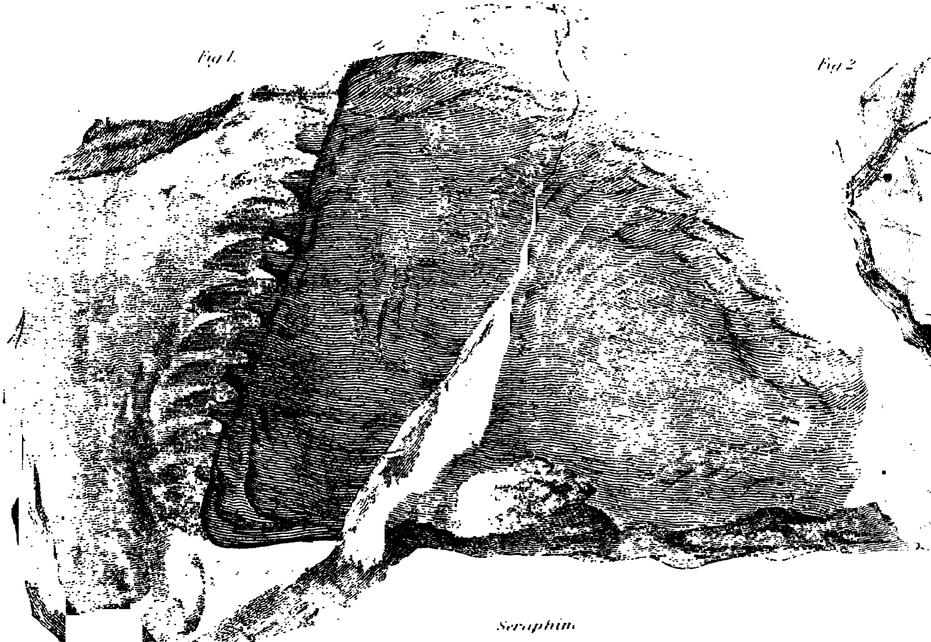
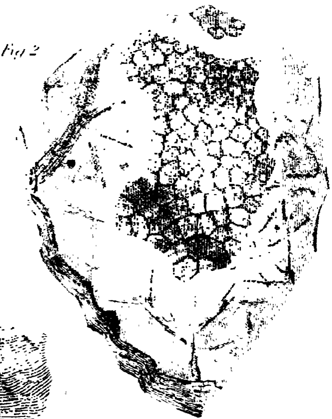


Fig 2.



Seraphin

seems to have had cotemporaries of the same family, whose construction in the divisions of the flap resembled more the lobsters of the present day; and the reader may see in the subjoined print the representation of a very characteristic fragment of an animal of this commoner type, from the Middle Sandstones of Forfarshire. (See Plate IX., fig. 1.) It is a terminal flap—one of several divisions—curi ously fretted by scale-like markings, and bearing on its lower edge a fringe, cut into angular points, somewhat in the style of the Vandyke edgings of a ruff or the lacings of a dead-dress. It may be remarked, in passing, that our commoner lobsters bear, on the corresponding edge, fringes of strong reddish-coloured hair. The form altogether, from its wing-like appearance, its feathery markings, and its angular points, will suggest to the reader the origin of the name given it by the Forfarshire workmen. With another such flap spreading out in the contrary direction, and a periwigged head between them, we would have one of the sandstone cherubs of our country church-yards complete.

There occur among the other organisms of Balruddery numerous ichthyodorulites—fin-spines, such as those to which I have called the attention of the reader in describing the thorny-finned fish of the lower formation. But the ichthyodorulites of Balruddery differ essentially from those of Caithness, Moray, and Cromarty. These last are described on both sides, in every instance, by either straight or slightly curved lines; whereas one of the describing lines in a Balruddery variety is broken by projecting

prickles that resemble sharp hooked teeth set in a jaw, or rather the entire ichthyodorulite resembles the spring of a wild rose-bush bearing its peculiar aquiline-shaped thorns on one of its sides. Buckland in his *Bridgewater Treatise*, and Lyell in his *Elements*, refer to this peculiarity of structure in ichthyodorulites of the latter formations. The hooks are invariably ranged on the concave or posterior edge of the spine, and were employed, it is supposed, in elevating the fin. Another ichthyodorulite of the formation resembles, in the Gothic cast of its roddings, those of the *Diplacanthus* of the Lower Old Red Sandstone described in pages 125 and 126 of the present volume, and figured in Plate VIII., fig. 2, except that it was proportionally stouter, and traversed at its base by lines running counter to the striæ that furrow it longitudinally. Of the other organisms of Balruddery I cannot pretend to speak with any degree of certainty. Some of them seem to have belonged to the *Radiata;* some are of so doubtful a character that it can scarce be determined whether they took their place among the forms of the vegetable or animal kingdoms. One organism in particular, which was at first deemed the jointed stem of some plant resembling a calamite of the Coal Measures, was found by Agassiz to be the slender limb of a crustacean. A minute description of this interesting deposit, with illustrative prints, would be of importance to science: it would serve to fill a gap in the scale. The geological pathway, which leads upwards to the present time from those ancient formations in which organic existence first began, has been the work of well-nigh

as many hands as some of our longer railroads: each contractor has taken his part; very extended parts have fallen to the share of some, and admirably have they executed them; but the pathway is not yet complete, and the completion of a highly curious portion of it awaits the further labours of Mr. Webster of Balruddery.

A considerable portion of the rocks of this middle formation in Scotland are of a bluish-grey colour: in Balruddery they resemble the mudstones of the Silurian System; they form at Carmylie the fissile bluish-grey pavement, so well known in commerce as the pavement of Arbroath; they occur as a hard micaceous building-stone in some parts of Fifeshire; in others they exist as beds of friable stratified clay, that dissolve into unctuous masses where washed by the sea. In England the formation consists, throughout its entire depth, of beds of red and green marl, with alternating beds of the nodular limestones, to which it owes it name, and with here and there an interposing band of indurated sandstone.

The Cornstone formation is more extensively developed in Forfarshire than in any other district in Scotland; and from this circumstance the result of the writer's observations regarding it, during the course of a recent visit, may be of some little interest to the reader. About two-thirds the entire area of this county is composed of Old Red Sandstone. It forms a portion of that great belt of the system which, extending across the island from the German Ocean to the Frith of Clyde, represents the southern bar of the huge sandstone frame in which the Highlands

of Scotland is set. The Grampians run along its inner edge—composing part of the primary nucleus which the frame encloses: the Sidlaw Hills run through its centre in a line nearly parallel to these, and separated from them by Strathmore, the great valley of Angus. The valley and the hills thus form, if I may so express myself, the mouldings of the frame—mouldings somewhat resembling the semi-recta of the architect. There is first, reckoning from the mountains downwards, an immense concave curve—the valley; then an immense convex one—the hills; and then a half curve bounded by the sea. The illustration may further serve to show the present condition of the formation: it is a frame much worn by denudation, and—just as in a *bona fide* frame—it is the higher mouldings that have suffered most. Layer after layer has been worn down on the ridges, exactly as on a raised moulding we may see the gold leaf, the red pigment, and the whiting, all ground down to the wood; while in the hollow moulding beside it, on the contrary, the gilt is still fresh and entire. We find in the hollows the superior layers of the frame still overlying the inferior ones, and on the heights the inferior ones laid bare. To descend in the system, therefore, we have to climb a hill—to rise in it, we have to descend into a valley. We find the lowest beds of the system anywhere yet discovered in the county, on the moory heights of Carmylie; its newer deposits may be found on the sea-shore, beside the limeworks of Hedderwick, and in the central hollows of Strathmore.

The most ancient beds in the county yet known

belong, as unequivocally shown by their fossils, to but the middle formation of the system. They have been quarried for many years in the parish of Carmylie; and the quarries, as may be supposed, are very extensive, stretching along a moory hill-side for considerably more than a mile, and furnishing employment to from sixty to a hundred workmen. The eye is first caught, in approaching them, as we surmount a long flat ridge, which shuts them out from the view of the distant sea, by what seems a line of miniature windmills, the sails flaring with red lead, and revolving with the lightest breeze at more than double the rate of the sails of ordinary mills. These are employed—a lesson probably borrowed from the Dutch—in draining the quarries, and throw up a very considerable body of water. The line of the excavations resembles a huge drain, with nearly perpendicular sides—a consequence of the regular and well-determined character of the joints with which the strata are bisected. The stone itself is a grey close-grained fissile sandstone, of unequal hardness, and so very tough and coherent—qualities which it seems to owe in part to the vast abundance of mica which it contains—that it is quite possible to strike a small hammer through some of the larger flags, without shattering the edges of the perforation. Hence its value for various purposes which common sandstone is too brittle and incoherent to serve. It is extensively used in the neighbourhood as a roofing slate; it is employed, too, in the making of water cisterns, grooved and jointed as if wrought out of wood, and for the tops of lobby and billiard tables. I have even seen snuff-boxes fashioned out

of it, as a sort of mechanical feat, by the workmen—a purpose, however, which it seems to serve only indifferently well—and single slabs of it cut into tolerably neat window frames for cottages. It is most extensively used, however, merely as a paving-stone for lobbies and lower floors, and the footways of streets. When first deposited, and when the creatures whose organic remains it still preserves careered over its numerous platforms, it seems to have existed as a fine muddy sand, formed apparently of disintegrated grauwacke rocks, analogous in their mineral character to the similarly coloured grauwacke of the Lammermuirs, or of primary slates ground down by attrition into mud, and mixed up with the pulverized fragments of schistose gneiss and mica schist.

I was first struck, on descending among the workmen, by the comparative abundance of the vegetable remains. In some parts of the quarries almost every layer of the strata is covered by carbonaceous markings—irregularly grooved stems, branching out into boughs at acute angles, and that at the first glance seem the miniature semblances of the trunks of gnarled oaks and elms blackened in a morass, and still retaining the rough bark chapped into furrows: oblong leaf-like impressions, too, and impressions of more slender form, that resemble the narrow parallel-edged leaves of the sea-grass weed. I observed, in particular, one large bunch of ribbon-like leaflets converging into a short stem, so that the whole resembled a scourge of cords; and I would fain have detached it from the rock, but it lay on a mouldering film of clay,

and broke up with my first attempt to remove it. A stalk of sea-grass weed plucked up by the roots, and compressed in a herbarium, would present a somewhat similar appearance. Among the impressions there occur irregularly-shaped patches, reticulated into the semblance of polygonal meshes. They remind one of pieces of ill-woven lace; for the meshes are unequal in size, and the polygons irregular. (See Plate IX., fig. 2.) When first laid open, every mesh is filled with a carbonaceous speck; and from their supposed resemblance to the eggs of the frog, the workmen term them *puddock spawn*. They are supposed by Mr. Lyell to form the remains of the eggs of some gasteropodus mollusc of the period. I saw one flagstone, in particular, so covered with these reticulated patches, and so abundant, besides, in vegetable impressions of both the irregularly furrowed and grass-weed-looking class, that I could compare it to only the bottom of a ditch beside a hedge, matted with withered grass, strewed with blackened twigs of the hawthorn, and mottled with detached masses of the eggs of the frog. All the larger vegetables are resolved into as pure a coal as the plants of the Coal Measures themselves—the kind of data, doubtless, on which unfortunate coal speculators have often earned disappointment at large expense. None of the vegetables themselves, however, in the least resemble those of the carboniferous period.

The animal remains, though less numerous, are more interesting. They are identical with those of the Den of Balruddery. I saw, in the possession of the superintendent of the quarries, a well-preserved

head of the *Cephalaspis Lyellii.* The crescent-shaped horns were wanting, and the outline a little obscure; but the eyes were better marked than in almost any other specimen I have yet seen, and the circular star-like tubercles which roughen the large occipital buckler, to which the creature owes its name, were tolerably well defined. I was shown the head of another individual of the same species in the centre of a large slab, and nothing could be more entire than the outline. The osseous plate still retained the original brownish-white hue of the bone, and its rádiated porous texture; and the sharp crescent-shaped horns were as sharply defined as during the lifetime of the strangely organized creature which they had defended. In both specimens the thin angular body was wanting. Like almost all the other fish of the Old Red Sandstone, the bony skeleton of the *Cephalaspis* was external—as much so as the shell of the crab or lobster: it presented at all points an armour of bone as complete as if it had been carved by the ivory-turner out of a solid block; while the internal skeleton, which in every instance has disappeared, seems to have been composed of cartilage. I have compared its general appearance to a saddler's cutting-knife;—I should, perhaps, have said a saddler's cutting-knife divested of the wooden handle—the broad bony head representing the blade, and the thin angular body the iron stem usually fixed in the wood. No existence of the present creation at all resembles the *Cephalaspis.* Were we introduced to the living creatures which now inhabit the oceans and rivers of Mars and Venus, we could find nothing among them

more strange in appearance, or more unlike our living acquaintances of the friths and streams, than the *Cephalaspides* of Carmylie.

I observed, besides, in the quarry, remains of the huge crustacean of Balruddery. The plates of the *Cephalaspis* retain the colour of the original bone; the plates of the crustacean, on the contrary, are of a deep red tint, which contrasts strongly with the cold grey of the stone. They remind one, both in shape and hue, of pieces of ancient iron armour, fretted into semi-elliptical scales, and red with rust. I saw with one of the workmen what seemed to have been the continuous tail-flap of an individual of very considerable size. It seemed curiously puckered where it had joined to the body, much in the manner that a gown or Highlander's kilt is puckered where it joins to the waistband; and the outline of the whole plate was marked by what I may venture to term architectural elegance. The mathematician could have described it with his ruler and compasses. The superintendent pointed out to me another plate in a slab dressed for a piece of common pavement. It was a regularly formed parallelogram, and had obviously composed one of the jointed plates which had covered the creature's body. I could not so easily assign its place to yet a third plate in the possession of the Rev. Mr. Wilson of Carmylie. It is coloured, like the others, and, like them, too, fretted into minute scales, but the form is exactly that of a heart—not such a heart as the anatomist would draw, but such a heart rather as we see at times on valentines of the humbler order, or on the ace of hearts in a pack of cards. Possibly

enough it may have been the breast-plate of this antique crustacean of the Cornstones. The spawn of our common blue lobster is composed of spherical black grains, of nearly the size of mustard seed. It struck me as not very improbable that the reticulated markings of the flagstones of Carmylie may have been produced by the minute eggs of this fossil crustacean, covered up by some hastily-deposited layer of mingled mud and sand, and forced into the polygonal form by pressing against each other, and by the weight from above.

The grey fissile bed in which these organisms occur was perforated to its base on two several occasions, and in different parts of the quarries—in one instance, merely to ascertain its depth; in the other, in the course of excavating a tunnel. In the one case it was found to rest on a bed of trap, which seemed to have insinuated itself among the strata with as little disturbance, and which lay nearly as conformably to them as the greenstone bed of Salisbury Crags does to the alternating sandstones and clays which both underlie and overtop it. In the other instance the excavators arrived at a red aluminous sandstone, veined by a purplish-coloured oxide of iron. The upper strata of the quarry are overlaid by a thick bed of greyish-red conglomerate.

Leaving behind us the quarries of Carmylie, we descend the hill-side, and rise in the system as we lower our level and advance upon the sea. For a very considerable distance we find the rock covered up by a deep-red diluvial clay, largely charged with water-worn boulders, chiefly of the older primary rocks,

and of the sandstone underneath. The soil on the higher grounds is moory and barren—a consequence, in great part, of a hard ferruginous pan, which interposes like a paved floor between the diluvium and the upper mould, and which prevents the roots of the vegetation from striking downwards into the tenacious subsoil. From its impervious character, too, it has the effect of rendering the surface a bog for one-half the year, and an arid sun-baked waste for the other. It seems not improbable that the heaths which must have grown and decayed on these heights for many ages may have been main agents in the formation of this pavement of barrenness. Of all plants they are said to contain most iron. According to Fourcroy, a full twelfth part of the weight of oak, when dried, is owing to the presence of this almost universally diffused metal; and the proportion in our common heaths is still larger. It seems easy to conceive how that, as generation after generation withered on these heights, and were slowly resolved into a little mossy dust, the minute metallic particles which they had contained would be carried downwards by the rains through the lighter stratum of soil, till, reaching the impermeable platform of tenacious clay beneath, they would gradually accumulate there, and at length bind its upper layer, as is the nature of ferruginous oxide, into a continuous stony crust. Bog iron, and the clay ironstone, so abundant in the Coal Measures, and so extensively employed in our iron works, seem to have owed their accumulation in layers and nodules to a somewhat similar process, through the agency of vegetation. But I digress.

The rock appears in the course of the Elliot, a few hundred yards above the pastoral village of Arbirlot. We find it uptilted on a mass of clay-stone amygdaloid, that has here raised its broad back to the surface amid the middle shales and sandstones of the system. The stream runs over the intruded mass; and where the latter terminates, and the sandstones lean against it, the waters leap from the harder to the softer rock, immediately beside the quiet parish burying-ground, in a cascade of some eight or ten feet. From this point, for a full mile downwards, we find an almost continuous section of the sandstone—stratum leaning against stratum—in an angle of about thirty. The portion of the system thus exhibited must amount to many hundred yards in vertical extent; but as I could discover no data by which to determine regarding the space which may intervene between its lowest stratum and the still lower beds of Carmylie, I could form no guess respecting the thickness of the whole. In a bed of shale, about a quarter of a mile below the village, I detected several of the vegetable impressions of Carmylie, especially those of the grass-weed-looking class, and an imperfectly preserved organism resembling the parallelogrammical scale of a *Cephalaspis.* The same plants and animals seem to have existed on this high platform as on the Carmylie platform, far beneath.

A little farther down the course of the stream, and in the immediate neighbourhood of the old weather-worn tower of the Ouchterlonies, there occurs what seems a break in the strata. The newer sandstones seem to rest unconformably on the older sandstones which they overlie. The evening on which I explored

the course of the Elliot was drizzly and unpleasant, and the stream swollen by a day of continuous rain, and so I could not examine so minutely as in other circumstances I would have done, or as was necessary to establish the fact. In since turning over the *Elements* of Lyell, however, I find, in his section of Forfarshire, that a newer deposit of nearly horizontal strata of sandstone and conglomerate lies unconformably, in the neighbourhood of the sea, on the older sandstones of the district; and the appearances observed near the old tower, mark, it is probable, one of the points of junction—a point of junction also, if I may be so bold as venture the suggestion, of the formation of the *Holoptychius Nobilissimus* with the formation of the *Cephalaspis*—of the Quartzose conglomerate with the Cornstones. In my hurried survey, however, I could find none of the scales or plates of the newer ichthyolite in this upper deposit, though the numerous spherical markings of white, with their central points of darker colour, show that at one time the organisms of these upper beds must have been very abundant.

We pass to the upper formation of the system. Over the belt of mingled grey and red there occurs in the pyramid a second deep belt of red conglomerate and variegated sandstone, with a band of lime atop, and over the band a thick belt of yellow sandstone, with which the system terminates.* Thus the second

* There still exists some uncertainty regarding the order in which the upper beds occur. Mr. Duff of Elgin places the limestone band above the yellow sandstone; Messrs. Sedgwick and Murchison assign it an intermediate position between the red and yellow. The respective places of the grey and red sandstones are

pyramid consists mineralogically, like the first, of three great divisions or bands; its two upper belts belonging, like the three belts of the other, to but one formation—the formation known in England as the Quartzose Conglomerate. It is largely developed in Scotland. We find it spread over extensive areas in Moray, Fife, Roxburgh, and Berwick shires. In England it is comparatively barren in fossils: the only animal organic remains yet detected in it being a single scale of the *Holoptychius* found by Mr. Murchison; and though it contains vegetable organisms in more abundance, so imperfectly are they preserved, that little else can be ascertained regarding them than that they were land plants, but not identical with the plants of the Coal Measures. In Scotland the formation is richly fossiliferous, and the remains belong chiefly to the animal kingdom. It is richly fossiliferous, too, in Russia, where it was discovered by Mr. Murchison, during the summer of last year, spread over areas many thousand square miles in extent. And there, as in Scotland, the *Holoptychius* seems its most characteristic fossil.

also disputed, and by very high authorities; Dr. Fleming holding that the grey sandstones overlie the red (see *Cheek's Edinburgh Journal* for February 1831), and Mr. Lyell, that the red sandstones overlie the grey (see *Elements of Geology*, first edit., pp. 99, 100). The order adopted above consorts best with the results of the writer's observations, which have, however, been restricted chiefly to the north country. He assigns to the limestone band the middle place assigned to it by Messrs. Sedgwick and Murchison, and to the grey sandstone the inferior position assigned to it by Mr. Lyell; aware, however, that the latter deposit has not only a coping, but also a basement, of red sandstone—the basement forming the upper member of the lower formation.

The fact seems especially worthy of remark. The organisms of some of the newer formations differ entirely, in widely-separated localities, from their cotemporary organisms, just as, in the existing state of things, the plants and animals of Great Britain differ from the plants and animals of Lapland or of Sierra Leone. A geologist who has acquainted himself with the belemnites, baculites, turrilites, and sea-urchins of the Cretaceous group in England and the north of France, would discover that he had got into an entirely new field among the hippurites, sphærulites, and nummulites of the same formations, in Greece, Italy, and Spain; nor, in passing to the tertiary deposits, would he find less striking dissimilarities between the gigantic mail-clad megatherium and huge mastodon of the Ohio and the La Plate, and the monsters, their cotemporaries, the hairy mammoth of Siberia, and the hippopotamus and rhinoceros of England and the Continent. In the more ancient geological periods, ere the seasons began, the case is essentially different; the cotemporary formations, when widely separated, are often very unlike in mineralogical character, but in their fossil contents they are almost always identical. In these earlier ages, the atmospheric temperature seems to have depended more on the internal heat of the earth, only partially cooled down from its original state, than on the earth's configuration or the influence of the sun. Hence a widely-spread equality of climate—a green-house equalization of heat, if I may so speak; and hence, too, it would seem, a widely-spread Fauna and Flora. The green-houses of Scotland and Sweden

produce the same plants with the green-houses of Spain and Italy; and when the world was one vast green-house, heated from below, the same families of plants, and the same tribes of animals, seem to have ranged over spaces immensely more extended than those geographical circles in which, in the present time, the same plants are found indigenous, and the same animals native. The fossil remains of the true Coal Measures are the same to the westward of the Alleghany Mountains as in New Holland, India, Southern Africa, the neighbourhood of Newcastle, and the vicinity of Edinburgh. And I entertain little doubt that, on a similar principle, the still more ancient organisms of the Old Red Sandstone will be found to bear the same character all over the world.

CHAPTER IX.

Fossils of the Upper Old Red Sandstone much more imperfectly preserved than those of the Lower—The Causes obvious—Difference between the two Groups, which first strikes the Observer, a Difference in size—The *Holoptychius* a characteristic Ichthyolite of the Formation—Description of its huge Scales—Of its Occipital Bones, Fins, Teeth, and general Appearance—Cotemporaries of the *Holoptychius*—Sponge-like Bodies—Plates resembling those of the Sturgeon—Teeth of various Forms, but all evidently the Teeth of Fishes—Limestone Band, and its probable Origin—Fossils of the Yellow Sandstone—The *Pterichthys* of Dura Den—Member of a Family peculiarly characteristic of the System—No intervening Formation between the Old Red Sandstone and the Coal Measures—The *Holoptychius* cotemporary for a time with the *Megalichthys*—The Columns of Tubal Cain.

The different degrees of entireness in which the geologist finds his organic remains, depend much less on their age than on the nature of the rock in which they occur; and as the arenaceous matrices of the Upper and Middle Old Red Sandstones have been less favourable to the preservation of their peculiar fossils than the calcareous and aluminous matrices of the Lower, we frequently find the older organisms of the system fresh and unbroken, and the more modern existing as mere fragments. A fish thrown into

a heap of salt would be found entire after the lapse of many years; a fish thrown into a heap of sand would disappear in a mass of putrefaction in a few weeks; and only the less destructible parts, such as the teeth, the harder bones, and perhaps a few of the scales, would survive. Now, limestone, if I may so speak, is the preserving salt of the geological world; and the conservative qualities of the shales and stratified clays of the Lower Old Red Sandstone are not much inferior to those of lime itself; while, in the Upper Old Red, we have merely beds of consolidated sand, and these, in most instances, rendered less conservative of organic remains than even the common sand of our shores, by a mixture of the red oxide of iron. The older fossils, therefore, like the mummies of Egypt, can be described well-nigh as minutely as the existences of the present creation; the newer, like the comparatively modern remains of our church-yards, exist, except in a few rare cases, as mere fragments, and demand powers such as those of a Cuvier or an Agassiz to restore them to their original combinations.

But cases, though few and rare, do occur in which, through some favourable accident connected with the death or sepulture of some individual existence of the period, its remains have been preserved almost entire; and one such specimen serves to throw light on whole heaps of the broken remains of its cotemporaries. The single elephant, preserved in an iceberg beside the Arctic Ocean, illustrated the peculiarities of the numerous extinct family to which it belonged, whose bones and huge tusks whiten the wastes of Siberia. The human body found in an Irish bog, with the

ancient sandals of the country still attached to its feet by thongs, and clothed in a garment of coarse hair, gave evidence that bore generally on the degree of civilization attained by the inhabitants of an entire district in a remote age. In all such instances the character and appearance of the individual bear on those of the tribe. In attempting to describe the organisms of the Lower Old Red Sandstone, where the fossils lie as thickly in some localities as herrings on our coasts in the fishing season, I felt as if I had whole tribes before me. In describing the fossils of the Upper Old Red Sandstone I shall have to draw mostly from single specimens. But the evidence may be equally sound so far as it goes.

The difference between the superior and inferior groups of the system which first strikes an observer, is a difference in the size of the fossils of which these groups are composed. The characteristic organisms of the Upper Old Red Sandstone are of much greater bulk than those of the Lower, which seem to have been characterized by a mediocrity of size throughout the entire extent of the formation. The largest ichthyolites of the group do not seem to have much exceeded two feet or two feet and a half in length; its smaller average from an inch to three inches. A jaw, in the possession of Dr. Traill—that of an Orkney species of *Platygnathus*, and by much the largest in his collection—does not exceed in bulk the jaw of a full-grown coal-fish or cod; his largest *Coccosteus* must have been a considerably smaller fish than an ordinary-sized turbot; the largest ichthyolite found by the writer was a *Diplopterus*, of, however, smaller

dimensions than the ichthyolite to which the jaw in the possession of Dr. Traill must have belonged; the remains of another *Diplopterus* from Gamrie, the most massy yet discovered in that locality, seem to have composed the upper parts of an individual about two feet and a half in length. The fish, in short, of the lower ocean of the Old Red Sandstone—and I can speak of it throughout an area which comprises Orkney and Inverness, Cromarty and Gamrie, and which must have included about ten thousand square miles—ranged in size between the stickleback and the cod; whereas some of the fish of its upper ocean were covered by scales as large as oyster-shells, and armed with teeth that rivalled in bulk those of the crocodile. They must have been fish on an immensely larger scale than those with which the system began. There have been scales of the *Holoptychius* found in Clashbennie which measure three inches in length by two and a half in breadth, and a full eighth part of an inch in thickness. There occur occipital plates of fishes in the same formation in Moray, a full foot in length by half a foot in breadth. The fragment of a tooth still attached to a piece of the jaw, found in the sandstone cliffs that overhang the Findhorn, measures an inch in diameter at the base. A second tooth of the same formation, of a still larger size, disinterred by Mr. Patrick Duff from out the conglomerates of the *Scat Craig*, near Elgin, and now in his possession, measures two inches in length by rather more than an inch in diameter. (See Plate X., fig. 4.) There occasionally turn up in the sandstones of Perthshire ichthyodorulites that in bulk and appearance resemble the teeth

Cephalaspis Lyellii. Agass.

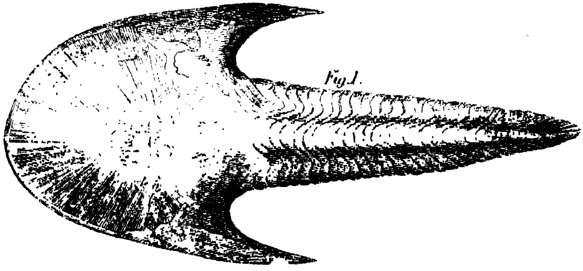


Fig. 1.

Holoptychius Nobilissimus Ag

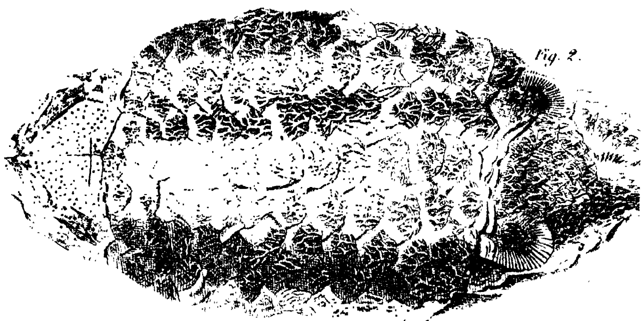


Fig. 2.

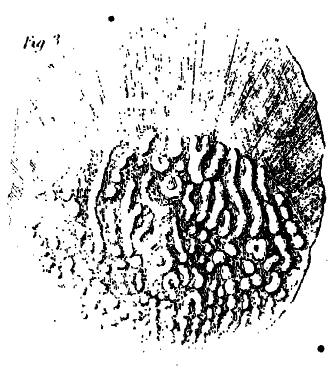


Fig. 3

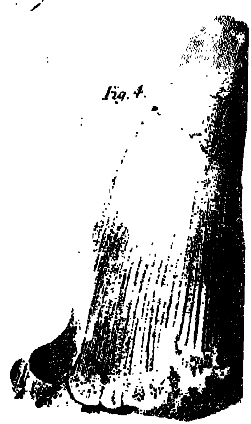


Fig. 4.

of a harrow rounded at the edges by a few months' wear, and which must have been attached to fins not inferior in general bulk to the dorsal fin of an ordinary-sized porpoise. In short, the remains of a Patagonian burying-ground would scarcely contrast more strongly with the remains of that battle-field described by Addison, in which the pigmies were annihilated by the cranes, than the organisms of the upper formation of the Old Red Sandstone contrast with those of the lower.*

Of this upper formation the most characteristic and most abundant ichthyolite, as has been already said, is the *Holoptychius.* The large scales and plates, and the huge teeth, belong to this genus. It was first introduced to the notice of geologists in a paper read before the Wernerian Society in May 1830, by Professor Fleming, and published by him in the February of the following year, in *Check's Edinburgh Journal.* Only detached scales and the fragment of a tooth had as yet been found; and these he minutely described as such, without venturing to hazard a conjecture regarding the character or family of the animal to which they had belonged. They were submitted

* I have permitted this paragraph to remain as originally written, though the comparatively recent discovery of a gigantic *Holoptychius* (?) in the Lower Old Red Sandstone of Thurso, by Mr. Robert Dick of that place (see introductory note), bears shrewdly against its general line of statement. But it will, at least, serve to show how large an amount of negative evidence may be dissipated by a single positive fact, and to inculcate on the geologist the necessity of cautious induction. An individual *Holoptychius* of Thurso must have been at least thrice the size of the *Holoptychius* of the Upper Old Red formation, as exhibited in the specimen of Mr. Noble of St. Madoes.

some years after to Agassiz, by whom they were referred, though not without considerable hesitation, to the genus *Gyrolepis;* and the doubts of both naturalists serve to show how very uncertain a guide mere analogy proves to even men of the first order, when brought to bear on organisms of so strange a type as the ichthyolites of the Old Red Sandstone. At this stage, however, an almost entire specimen of the creature was discovered in the sandstones of Clashbennie, by the Rev. James Noble of St. Madoes, a gentleman who, by devoting his leisure hours to Geology, has extended the knowledge of this upper formation, and whose name has been attached by Agassiz to its characteristic fossil, now designated the *Holoptychius Nobilissimus.* His specimen at once decided that the creature had been no *Gyrolepis*, but the representative of a new genus not less strangely organized, and quite as unlike the existences of the present times as any existence of all the past. So marked are the peculiarities of the *Holoptychius*, that they strike the commonest observer.

The scales are very characteristic. They are massy elliptical plates, scarcely less bulky in proportion to their extent of surface than our smaller copper coin, composed internally of bone, and externally of enamel, and presenting on the one side a porous structure, and on the other, when well preserved, a bright glossy surface. The upper or glossy side is the more characteristic of the two. I have placed one of them before me. Imagine an elliptical ivory counter, an inch and a half in length by an inch in breadth, and nearly an eighth part of an inch in thickness, the

larger diameter forming a line which, if extended, would pass longitudinally from head to tail through the animal which the scale covered. On the upper or anterior margin of this elliptical counter, imagine a smooth selvedge or border three-eighth parts of an inch in breadth. Beneath this border there is an inner border of detached tubercles, and beneath the tubercles, large undulating furrows, which stretch longitudinally towards the lower end of the ellipsis. Some of these waved furrows run unbroken and separate to the bottom, some merge into their neighbouring furrows at acute angles, some branch out and again unite, like streams which enclose islands, and some break into chains of detached tubercles. (See Plate X., fig 3.) No two scales exactly resemble one another in the minuter peculiarities of their sculpture, if I may so speak, just as no two pieces of lake or sea may be roughened after exactly the same pattern during a gale; and yet in general appearance they are all wonderfully alike. Their *style* of sculpture is the same—a style which has sometimes reminded me of the Runic knots of our ancient north-country obelisks. Such was the scale of the creature. The head, which was small, compared with the size of the body, was covered with bony plates, roughened after a pattern somewhat different from that of the scales, being tubercled rather than ridged; but the tubercles present a confluent appearance, just as chains of hills may be described as confluent, the base of one hill running into the base of another. The operculum seems to have been covered by one entire plate—a peculiarity observable, as has been remarked, among

some of the ichthyolites of the Lower Old Red Sandstone, such as the *Diplopterus*, *Dipterus*, and *Osteolepis*. And it, too, has its field of tubercles, and its smooth marginal selvedge or border, on which the lower edges of the upper occipital plates seem to have rested, just as in the roof of a slated building part of the lower tier of slates is overtopped and covered by the tier above. The scales towards the tail suddenly diminish at the ventral fins to about one-fourth the size of those on the upper part of the body; the fins themselves are covered at their bases, which seem to have been thick and fleshy like the base of the pectoral fin in the cod or haddock, with scales still more minute; and from the scaly base the rays diverge like the radii of a circle, and terminate in a semicircular outline. The ventrals are placed nearer the tail, says Agassiz, than in any other ganoid fish. (See Plate X., fig. 2.)

But no such description can communicate an adequate conception to the reader of the strikingly picturesque appearance of the *Holoptychius*, as shown in Mr. Noble's splendid specimen. There is a general massiveness about the separate portions of the creature, that imparts ideas of the gigantic, independently of its bulk as a whole; just as a building of moderate size, when composed of very ponderous stones, has a more imposing effect than much larger buildings in which the stones are smaller. The body measures a foot across, by two feet and a half in length, exclusive of the tail, which is wanting; but the armour in which it is cased might have served a crocodile or alligator of five times the size. It lies on its back, on

a mass of red sandstone; and the scales and plates still retain their bony colour, slightly tinged with red, like the skeleton of some animal that had lain for years in a bed of ferruginous marl or clay. The outline of the occipital portion of the specimen forms a low Gothic arch, of an intermediate style between the round Saxon and the pointed Norman. This arch is filled by two angular pane-like plates, separated by a vertical line, that represents, if I may use the figure, the dividing astragal of the window: and the under jaw, with its two sweeping arcs or branches, constitutes the frame. All of the head which appears is that under portion of it which extends from the upper part of the belly to the snout. The belly itself is thickly covered by huge carved scales, that, from their massiveness and regular arrangement, remind one of the flags of an ancient stone roof. The carving varies as they descend towards the tail, being more in the ridged style below, and more in the tubercled style above. So fairly does the creature lie on its back, that the ventral fins have fallen equally, one on each side, and, from their semicircular form, remind one of the two pouch-holes in a lady's apron, with their laced flaps. The entire outline of the fossil is that of an elongated ellipsis, or rather spindle, a little drawn out towards the caudal extremity. The places of all the fins are not indicated, but, as shown by other specimens, they seem to have been crowded together towards the lower extremity, like those of the *Glyptolepis*, an ichthyolite which, in more than one respect, the *Holoptychius* must have resembled, and which, from this peculiarity, presents

a brush-like appearance—the head and shoulders representing the handle, and the large and thickly-clustered fins the spreading bristles.*

Some of the occipital bones of the *Holoptychius* are very curious and very puzzling. There are pieces rounded at one of the ends, somewhat in the manner of the neck-joints of our better-known quadrupeds, and which have been mistaken for vertebræ, but which present evidently, at the apparent joint, the enamel peculiar to the outer surface of all the plates and scales of the creature, and which belonged, it is probable, to the snout. There are saddle-shaped bones, too, which have been regarded as the central occipital plates of a new species of *Coccosteus*, but whose style of confluent tubercle belongs evidently to the *Holoptychius*. The jaws are exceedingly curious. They are composed of as solid bone as we usually find in the jaws of mammalia; and the outer surface, which is covered in animals of commoner structure with portions of the facial integuments, we find polished and japanned, and fretted into tubercles. The jaws of the creature, like those of the *Osteolepis* of the lower formation, were naked jaws; it is, indeed, more than probable that all its real bones were so, and that the internal skeleton was cartilaginous. A row of thickly-set pointed teeth ran along the japanned edges of the mouth—what in fish of the ordinary construction would be the lips; and inside this row there was a second and widely-set row of at least twenty times

* There are now six species of *Holoptychius* enumerated—*H. Andersoni*, *H. Flemingii*, *H. giganteus*, *H. Murchisoni*, *H. Noblissimus*, and *H. Omaliusii*.

the bulk of the other, and which stood up over and beyond it, like spires in a city over the rows of lower buildings in front. A nearly similar disposition of teeth seems also to have characterized the *Holoptychius* of the Coal Measures, but the contrast in size was some what less marked. One of the most singularly-formed bones of the formation will be found, I doubt not, when perfect specimens of the upper part of the creature shall be procured, to have belonged to the *Holoptychius*. It is a huge ichthyodorulite, formed, box-like, of four nearly rectangular planes, terminating in a point, and ornamented on two of the sides by what in a work of art the reader would at once term a species of Chinese fret-work. Along the centre there runs a line of lozenges, slightly truncated where they unite, just as, in plants that exhibit the cellular texture, the lozenge-shaped cells may be said to be truncated. At the sides of the central line, there run lines of half lozenges, which occupy the space to the edges. Each lozenge is marked by lines parallel to the lines which describe it, somewhat in the manner of the plates of the tortoise. The centre of each is thickly tubercled; and what seems to have been the anterior plane of the ichthyodorulite is thickly tubercled also, both in the style of the occipital plates and jaws of the *Holoptychius*. This curious bone, which seems to have been either hollow inside, or, what is more probable, filled with cartilage, measures, in some of the larger specimens, an inch and half across at the base on its broader planes, and rather more than half an inch on its two narrower ones.*

* This bone has been since assigned by Agassiz to a new

Geologists have still a great deal to learn regarding the cotemporaries of the *Holoptychius Nobilissimus.* The lower portion of that upper formation to which it more especially belongs—the portion represented in our second pyramid by the conglomerate and sandstone bar—though unfavourable to the preservation of animal remains, represents assuredly no barren period. It has been found to contain bodies apparently organic, that vary in shape like the sponges of our exisiting seas, which in general appearance they somewhat resemble, but whose class, and even kingdom, are yet to fix.* It contains, besides, in considerable abundance,

genus, of which no other fragments have yet been found, but which has been named provisionally *Placothorax paradoxus.*

* These organisms, if in reality such, are at once very curious and very puzzling. They occur in some localities in great abundance. A piece of Clashbennie flagstone, somewhat more than two feet in length, by fifteen inches in breadth, kindly sent me for examination by the Rev. Mr. Noble of St. Madoes, bears no fewer than twelve of them on its upper surface, and presents the appearance of a piece of rude sculpture, not very unlike those we sometimes see in country church-yards, on the tombstones of the times of the Revolution. All the twelve vary in appearance. Some of them are of a pear shape—some are irregularly oval—some resemble short cuts of the bole of a tree—some are spread out like ancient manuscripts partially unrolled—one of the number seems a huge though not over-neatly formed acorn, an apprentice mason's first attempt—the others are of a shape so irregular as to set comparison and description at defiance. They almost all agree, however, when cut transversely, in presenting flat elliptical arcs as their sectional lines—in having an upper surface comparatively smooth, and an under surface nearly parallel to it thickly corrugated—and in being all coated with a greasy shining clay, of a deeper red than the surrounding stone. I was perhaps rather more confident of their organic character after I had examined a few merely detached specimens, than now that I have seen a dozen of them together. It seems at least a circumstance

though in a state of very imperfect preservation, scales that differ from those of the *Holoptychius* and from one another. One of these figured and described by Professor Fleming in *Cheek's Edinburgh Journal*, bearing on its upper surface a mark like a St. Andrew's cross, surrounded by tubercled dottings, and closely resembling in external appearance some of the scales of the common sturgeon, "may be referred with some probability," says the Professor, "to an extinct species of the genus *Accipenser*.* The deposit, too, abounds in teeth, various enough in their forms

to awaken doubt, that though they occur in various positions on the slab—some extending across it, some lying diagonally, some running lengthwise—the corrugations of their under surfaces should run lengthwise in all—furrowing them in every possible angle, and giving evidence, not apparently to the influences of an organic law internal to each, but of the operation of some external cause acting on the whole in one direction.

* May I crave the attention of the reader to a brief statement of fact? I have said that Professor Fleming, when he minutely described the scales of the *Holoptychius*, hazarded no conjecture regarding the generic character of the creature to which they had belonged; he merely introduced them to the notice of the public as the scales of some "vertebrated animal, probably those of a fish." I now state that he described the scales of a cotemporary ichthyolite as bearing, in external appearance, a "close resemblance to some of the scales of the common sturgeon." It has been asserted, that it was the scales of the *Holoptychius* which he thus described, "referring them to an extinct species of the genus *Accipenser;*" and the assertion has been extensively credited, and by some of our highest geological authorities. Agassiz himself, evidently in the belief that the Professor had fallen into a palpable error, deems it necessary to prove that the *Holoptychius* could have borne "no relation to the *Accipenser* or sturgeon." Mr. Murchison, in his *Silurian System*, refers also to the supposed mistake. The person with whom the misunderstanding seems to have originated is the Rev. Dr. Anderson of

to indicate a corresponding variety of families and genera among the ichthyolites to which they belonged. Some are nearly straight, like those of the *Holopty-*

Newburgh. About a twelvemonth after the discovery of Professor Fleming in the sandstones of Drumdryan, a similar discovery was made in the sandstones of Clashbennie by a geologist of Perth, who, on submitting his new-found scales to Dr. Anderson, concluded, with the Doctor, that they could not be other than *oyster shells;* though, eventually, on becoming acquainted with the decision of Professor Fleming regarding them, both gentlemen were content to alter their opinion, and to regard them as scales. The Professor in his paper on the Old Red Sandstone, in *Cheek's Journal*, referred incidentally to the *oyster shells* of Clashbennie—a somewhat delicate subject of allusion; and in Dr. Anderson's paper on the same formation, which appeared about seven years after, in the *New Journal* of Professor Jameson, the geological world was told, for the first time, that Professor Fleming had described a scale of Clashbennie *similar to those of Drumdryan*, (*i.e.*, those of the *Holoptychius*), as bearing a "close resemblance to some of the scales on the common sturgeon," and as probably referable to some "extinct species of the genus *Accipenser*." Now, Professor Fleming, instead of stating that the scales were at all similar, had stated very pointedly that they were entirely different; and not only had he *described* them as different, but he had also *figured* them as different, and had placed the figures side by side, that the difference might be the better seen. To the paper of the Professor, which contained this statement, and to which these figures were attached, Dr. Anderson referred, as "read before the Wernerian Society;"—he quoted from it in the Professor's words—he drew some of the more important facts of his own paper from it—in his late Essay on the Geology of Fife he has availed himself of it still more largely, though with no acknowledgment—it has constituted, in short, by far the most valuable of all his discoveries in connection with the Old Red Sandstone, and apparently the most minutely examined; and yet so completely did he fail to detect Professor Fleming's carefully-drawn distinction between the scales of the *Holoptychius* and those of its cotemporary, that when Agassiz, misled apparently by the Doctor's own statement, had set himself to show that the scaly giant of the formation could have been no sturgeon, the Doctor

chius of the Coal Measures; some are bent, like the beak of a hawk or eagle, into a hook-form; some incline first in one direction and then in the opposite

had the passage in which the naturalist established the fact transferred into a Fife newspaper, with, of course, the laudable intention of preventing the Fife public from falling into the *absurd mistake* of Professor Fleming. There seems to be something rather inexplicable in all this; but there can be little doubt Dr. Anderson could satisfactorily explain the whole matter without once referring to the *oyster shells* of Clashbennie. It is improbable that he could have wished or intended to injure the reputation of a gentleman to whose freely-imparted instructions he is indebted for by much the greater portion of his geological skill—whose remarks, written and spoken, he has so extensively appropriated in his several papers and essays—and whose character is known far beyond the limits of his country, for untiring research, philosophic discrimination, and all the qualities which constitute a naturalist of the highest order. Dr. Johnston of Berwick, in his *History of British Zoophytes* (a work of an eminently scientific character), justly "ascribes to the labours and writings" of Professor Fleming "no small share in diffusing that taste for Natural History which is now abroad." And as an interesting corroboration of the fact, I may state, that Dr. Malcolmson of Madras, lately found an elegant Italian translation of *Fleming's Philosophy of Zoology*, high in repute among the elite of Rome. Lest it should be supposed I do Dr. Anderson injustice in these remarks, I subjoin the grounds of them in the following extracts from Professor Fleming's paper in *Cheek's Journal*, and from the paper in *Jameson's New Edinburgh Journal*, in which the Doctor purports to give a digest of the former, without once referring, however, to the periodical in which it is to be found.

"In the summer of 1827," says Dr. Fleming, "I obtained from Drumdryan quarry, to the south of Cupar, situate in the higher strata of yellow sandstone, certain organisms, which I readily referred to the scales of vertebrated animals, probably those of a fish. The largest (see Plate II., fig. 1, '*figure of a scale of the Holoptychius*') was one inch and one-tenth in length, about one inch and two-tenths in breadth, and not exceeding the fiftieth of an inch in thickness. The part which, when in its natural posi-

one, like nails that have been drawn out of a board by the carpenter at two several wrenches, and bent in opposite angles at each wrench; some are bulky and

tion, had been imbedded in the cuticle, is comparatively smooth, exhibiting, however, in a very distinct manner the semi-circularly-parallel layers of growth with obsolete diverging striæ, giving to the surface, when under a lens, a reticulated aspect. The part naturally exposed is marked with longitudinal, waved, rounded, anastomosing ridges, which are smooth and glossy. The whole of the inside of the scale is smooth, though exhibiting with tolerable distinctness the layers of growth. The form and structure of the object indicated plainly enough that it had been a scale, a conclusion confirmed by the detection of the phosphate of lime in its composition. At this period I inserted a short notice of the occurrence of these scales in our provincial newspaper, the *Fife Herald*, for the purpose of attracting the attention of the workmen and others in the neighbourhood, in order to secure the preservation of any other specimens which might occur.

"Nearly a year after these scales had been discovered, not only in the upper, but even in some of the lower beds of the Yellow Sandstone, I was informed that *oyster shells* had been found in a quarry in the Old Red Sandstone at Clashbennie, near Errol in Perthshire, and that specimens were in the possession of a gentleman in Perth. Interested in the intelligence, I lost no time in visiting Perth, and was gratified to find that the supposed oyster shells were in fact similar to those which I had ascertained to occur in a higher part of the series. The scales were, however, of a larger size, some of them exceeding three inches in length, and one-eighth of an inch in thickness. Upon my visit to the quarry, I found the scales, as in the Yellow Sandstone, most abundant in those parts of the rock which exhibited a brecciated aspect. Many patches a foot in length, full of scales, have occurred; but as yet no entire impression of a fish has been obtained.

"Another scale, DIFFERING FROM THOSE ALREADY NOTICED (see Plate II., fig. 3, '*figure of an oblong tubercled plate traversed diagonally by lines, which, bisecting one another a little above the centre, resembles a St. Andrew's cross, and marked on the edges by faintly radiating lines*'), is about an inch and a quarter in length, and an inch in breadth. In external appearance it bears a very

squat, some long and slender; and in almost all the varieties, whether curved or straight, squat or slim, the base is elegantly striated like the flutings of a column. In the splendid specimen found in the sandstones of the Findhorn, the tooth is still attached to a portion of the jaw, and shows, from the nature of the attachment, that the creature to which it belonged must have been a true fish, not a reptile. The same peculiarity is observable in two other very fine specimens in the collection of Mr. Patrick Duff of Elgin. Both in saurians and in toothed cetaceæ, such as the porpoise, the teeth are inserted in sockets. In the ichthyolites of this formation, so far as these are illustrated by its better specimens, the teeth, as in existing fish, are merely placed flat upon the jaw, or in shallow pits, which seem almost to indicate that the contrivance of sockets might be afterwards resorted to. Immediately over the sandstone and conglome-

close resemblance to some of the scales on the common sturgeon, and may, with some probability, be referred to an extinct species of the genus *Accipenser*." (*Cheek's Edinburgh Journal*, Feb. 1831, p. 85.)

"Dr. Fleming, in 1830," says Dr. Anderson, "read before the Wernerian Society a notice 'on the occurrence of scales of vertebrated animals in the Old Red Sandstone of Fifeshire.' These organisms, as described by him, occurred in the Yellow Sandstone of Drumdryan and the Grey Sandstone of Parkhill. From the former locality scales of a fish were obtained. . . . . . The same paper (Professor Fleming's) contains a notice of SIMILAR SCALES in the Old Red Sandstone of Clashbennie, near Errol, in Perthshire, ONE OF WHICH is described as bearing 'a very close resemblance to some of the scales on the common sturgeon, and may with some probability be referred to an extinct species of the genus *Accipenser*.'" (*Prof. Jameson's Edin. New Phil. Journal*, Oct. 1837, p. 138.)

rate belt in which these organisms occur there rests, as has been said, a band of limestone, and over the limestone, a thick bed of yellow sandstone, in which the system terminates, and which is overlaid in turn by the lower beds of the carboniferous group.

The limestone band is unfossiliferous, and, resembling, in mineralogical character, the Cornstones of England and Wales, it has been described as the Cornstone of Scotland; but the fact merely furnishes one illustration of many, of the inadequacy of a mineralogical nomenclature for the purposes of the geologist. In the neighbourhood of Cromarty the lower formation abounds in beds of nodular limestone, identical in appearance with the Cornstone;—in England similar beds occur so abundantly in the middle formation, that it derives its name from them;—in Fife they occur in the upper formation exclusively. Thus the formation of the *Coccosteus* and *Dipterus* is a Cornstone formation in the first locality; that of the *Cephalaspis* and the gigantic lobster in the second; that of the *Holoptychius Nobilissimus* in the third. We have but to vary our field of observation to find all the formations of the system *Cornstone formations* in turn. The limestone band of the upper member presents exactly similar appearances in Moray as in Fife. It is in both of a yellowish-green or grey colour, and a concretionary structure, consisting of softer and harder portions, that yield so unequally to the weather, as to exhibit in exposed cliffs and boulders a brecciated aspect, as if it had been a mechanical, not a chemical deposit; though its origin must unquestionably have been chemical. It contains minute crystals

of galena, and abounds in masses of a cherty, siliceous substance that strike fire with steel, and which, from the manner in which they are incorporated with the rock, show that they must have been formed along with it. From this circumstance, and from the general resemblance it bears to the deposits of the thermal waters of volcanic districts which precipitate siliceous mixed with calcareous matter, it has been suggested, and by no mean authority, that it must have derived its origin from hot springs. The bed is several yards in thickness; and as it appears both in Moray and in Fife, in localities at least a hundred and twenty miles apart, it must have been formed, if formed at all in this manner, at a period when the volcanic agencies were in a state of activity at no great distance from the surface.

The upper belt of yellow stone, the terminal layer of the pyramid, is fossiliferous both in Moray and Fife—more richly so in the latter county than even the conglomerate belt that underlies it, and its organisms are better preserved. It was in this upper layer, in Drumdryan quarry, to the south of Cupar, that Professor Fleming found the first-discovered scales of the *Holoptychius*. At Dura Den, in the same neighbourhood, a singularly rich deposit of animal remains was laid open a few years ago by some workmen when employed in excavating a water-course for a mill. The organisms lay crowded together, a single slab containing no fewer than thirty specimens, and all in a singularly perfect state of preservation. The whole space excavated did not exceed forty square yards in extent, and yet in these

forty yards there were found several genera of fishes new to Geology, and not yet figured nor described—a conclusive proof in itself that we have still very much to learn regarding the fossils of the Old Red Sandstone. By much the greater portion of the remains disinterred on this occasion were preserved by a lady in the neighbourhood; and the news of the discovery spreading over the district, the Rev. Dr. Anderson of Newburgh was fortunately led to discover them anew in her possession. The most abundant organism of the group was a variety of *Pterichthys*—the sixth species of this very curious genus now discovered in the Old Red Sandstones of Scotland; and as the Doctor had been lucky enough to find out for himself, some years before, that the scales of the *Holoptychius* were oyster shells, he now ascertained, with quite as little assistance from without, that the *Pterichthys* must have been surely a huge beetle. As a beetle, therefore, he figured and described it in the pages of a Glasgow topographical publication—*Fife Illustrated.* True, the characteristic elytra were wanting, and some six or seven tubercled plates substituted in their room; nor could the artist, with all his skill, supply the creature with more than two legs; but ingenuity did much for it notwithstanding; and by lengthening the snout, insect-like, into a point—by projecting an eye, insect-like, on what had mysteriously grown into a head—by rounding the body, insect-like, until it exactly resembled that of the large "twilight shard"—by exaggerating the tubercles seen in profile on the paddles until they stretched out, insect-like, into bristles—and by care-

fully sinking the tail, which was not insect-like, and for which no possible use could be discovered at the time—the Doctor succeeded in making the *Pterichthys* of Dura Den a very respectable beetle indeed. In a later publication, an Essay on the Geology of Fifeshire, which appeared in September last in the *Quarterly Journal of Agriculture*, he states, after referring to his former description, that among the higher geological authorities some were disposed to regard the creature as an extinct crustaceous animal, and some as belonging to a tribe closely allied to the *Chelonia*. Agassiz, as the writer of these chapters ventured some months ago to predict, has since pronounced it a fish—a *Pterichthys* specifically different from the five varieties of this ichthyolite which occur in the lower formation of the system, but generically the same. I very lately enjoyed the pleasure of examining the *bona fide* ichthyolite itself—one of the specimens of Dura Den, and apparently one of the more entire—in the collection of Professor Fleming. Its character as a *Pterichthys* I found very obvious; but neither the Professor nor myself was ingenious enough to discover in it any trace of the beetle of Dr. Anderson.*

* This interesting ichthyolite has since been regarded by Agassiz as the representative of a distinct genus, to which he gives the name *Pamphractus*. As exhibited in his restoration, however, it seems to differ little, if at all (if I may venture the suggestion), from a *Pterichthys* viewed on the upper side. In Agassiz's beautiful restoration of *Pterichthys*, and his accompanying prints of the fossils illustrative of that genus, it is, with but one doubtful exception, the under side of the animal that is presented; and hence a striking difference apparent between his representa-

Is it not interesting to find this very curious genus in both the lowest and highest fossiliferous beds of the system, and constituting, like the *Trilobite* genus of the Silurian group, its most characteristic organism? The *Trilobite* has a wide geological range, extending from the upper Cambrian rocks to the upper Coal Measures. But though the range of the genus is wide, that of every individual species of which it consists is very limited. The *Trilobites* of the upper Coal Measures differ from those of the Mountain Limestone; these again, with but one exception, from the *Trilobites* of the upper Silurian strata; these yet again from the *Trilobites* of the underlying middle beds; and these from the *Trilobites* that occur in the base of the system. Like the coins and medals of the antiquary, each represents its own limited period; and the whole taken together, yield a consecutive record. But while we find them merely scattered over the later formations in which they occur, and that very sparingly, in the Silurian System we find them congregated in such vast crowds, that their remains enter largely into the composition of many of the rocks which compose it. The *Trilobite* is the distinguishing organism of the group, marrying, if I may so express myself, its upper and lower beds; and what the *Trilobite* is to the Silurian formations, the *Pter-*

tions of the two genera, which would scarce obtain had the upper, not the under side of *Pterichthys* been exhibited. In verification of this remark, let the reader who has access to the *Monographic Poissons Fossiles* compare the restoration of *Pamphractus* (*Old Red*, Tab. VI., fig. 2), with the upper side of *Pterichthys* as figured in this volume, Plate I., fig. 1, making, of course, the due allowance for a difference of species.

ichthys seems to be to the formations of the Old Red Sandstone; with this difference, that, so far as is yet known, it is restricted to this system alone, occurring in neither the Silurian System below, nor in the Coal Measures above.

I am but imperfectly acquainted with the localities in which the upper beds of the Old Red Sandstone underlie the lower beds of the Coal Measures, or where any gradation of character appears. The upper yellow sandstone belt is extensively developed in Moray, but it contains no trace of carbonaceous matter in even its higher strata, and no other remains than those of the *Holoptychius* and its cotemporaries. The system in the north of Scotland differs as much from the carboniferous group in its upper as in its lower rocks; and a similar difference has been remarked in Fife, where the groups appear in contact a few miles to the west of St. Andrews. In England, in repeated instances, the junction, as shown by Mr. Murchison, in singularly instructive sections, is well marked, the carboniferous limestones resting conformably on the Upper Old Red Sandstone. No other system interposed between them.

There is a Rabbinical tradition that the sons of Tubal Cain, taught by a prophet of the coming deluge, and unwilling that their father's arts should be lost in it to posterity, erected two obelisks of brass, on which they inscribed a record of his discoveries, and that thus the learning of the family survived the cataclysm. The flood subsided, and the obelisks, sculptured from pinnacle to base, were found fast fixed in the rock. Now, the twin pyramids of the Old Red Sandstone,

with their party-coloured bars, and their thickly-crowded inscriptions, belong to a period immensely more remote than that of the columns of the antediluvians, and they bear a more certain record. I have, perhaps, dwelt too long on their various compartments; but the Artist by whom they have been erected, and who has preserved in them so wonderful a chronicle of his earlier works, has willed surely that they should be read, and I have perused but a small portion of the whole. Years must pass ere the entire record can be deciphered; but of all its curiously-inscribed sentences, the result will prove the same—they will all be found to testify of the Infinite Mind.

CHAPTER X.

Speculations in the Old Red Sandstone, and their Character—George, first Earl of Cromarty—His Sagacity as a Naturalist at fault in one instance—Sets himself to dig for Coal in the Lower Old Red Sandstone—Discovers a fine Artesian Well—Value of Geological Knowledge in an economic view—Scarce a Secondary Formation in the Kingdom in which Coal has not been sought for—Mineral Springs of the Lower Old Red Sandstone—Strathpeffer—Its peculiarities whence derived—Chalybeate Springs of Easter Ross and the Black Isle—Petrifying Springs—Building-Stone and Lime of the Old Red Sandstone—Its various Soils.

THERE has been much money lost, and a good deal won, in speculations connected with the Old Red Sandstone. The speculations in which money has been won have consorted, if I may so speak, with the character of the system, and those in which money has been lost have not. Instead, however, of producing a formal chapter on the economic uses to which its various deposits have been applied, or the unfortunate undertakings which an acquaintance with its geology would have prevented, I shall throw together, as they occur to me, a few simple facts illustrative of both.

George, first Earl of Cromarty, seems, like his namesake and cotemporary, the too celebrated Sir

George M'Kenzie of Roseavoch, to have been a man of an eminently active and inquiring mind. He found leisure, in the course of a very busy life, to write several historical dissertations of great research, and a very elaborate *Synopsis Apocalyptica.* He is the author, too, of an exceedingly curious letter on the "Second Sight," addressed to the philosophic Boyle, which contains a large amount of amusing and extraordinary fact; and his description of the formation of a peat-moss in the central Highlands of Ross-shire has been quoted by almost every naturalist who, since the days of the sagacious nobleman, has written on the formation of peat. His life was extended to extreme old age; and as his literary ardour remained undiminished till the last, some of his writings were produced at a period when most other men are sunk in the incurious indifferency and languor of old age. And among these later productions are his remarks on peat. He relates, that when a very young man, he had marked, in passing on a journey through the central Highlands of Ross-shire, a wood of very ancient trees, doddered and moss-grown, and evidently passing into a state of death through the last stages of decay. He had been led by business into the same district many years after, when in middle life, and found that the wood had entirely disappeared, and that the heathy hollow which it had covered was now occupied by a green stagnant morass, unvaried in its tame and level extent by either bush or tree. In his old age he again visited the locality, and saw the green surface roughened with dingy-coloured hollows, and several Highlanders

engaged in it in cutting peat in a stratum several feet in depth. What he had once seen an aged forest had now become an extensive peat moss.

Some time towards the close of the seventeenth century he purchased the lands of Cromarty, where his turn for minute observation seems to have anticipated—little, however, to his own profit—some of the later geological discoveries. There is a deep wooded ravine in the neighbourhood of the town, traversed by a small stream, which has laid bare, for the space of about forty yards in the opening of the hollow, the grey sandstone and stratified clays of the inferior fish bed. The locality is rather poor in ichthyolites, though I have found in it, after minute search, a few scales of the *Osteolepis*, and on one occasion one of the better marked plates of the *Coccosteus;* but in the vegetable impressions peculiar to the formation it is very abundant. These are invariably carbonaceous, and are not unfrequently associated with minute patches of bitumen, which in the harder specimens present a coal-like appearance; and the vegetable impressions and the bitumen seem to have misled the sagacious nobleman into the belief that coal might be found on his new property. He accordingly brought miners from the south, and set them to bore for coal in the gorge of the ravine. Though there was probably a register kept of the various strata through which they passed, it must have long since been lost; but from my acquaintance with this portion of the formation, as shown in the neighbouring sections, where it lies uptilted against the granite gneiss of the Sutors, I think I could pretty nearly restore it. They

would first have had to pass for about thirty feet through the stratified clays and shales of the ichthyolite bed, with here and there a thin band of grey sandstone, and here and there a stratum of lime; they would next have had to penetrate through from eighty to a hundred feet of coarse red and yellow sandstone, the red greatly predominating. They would then have entered the great conglomerate, the lowest member of the formation; and in time, if they continued to urge their fruitless labours, they would arrive at the primary rock, with its belts of granite, and its veins and huge masses of hornblende. In short, there might be some possibility of their penetrating to the central fire, but none whatever of their ever reaching a vein of coal. From a curious circumstance, however, they were prevented from ascertaining, by actual experience, the utter barrenness of the formation.

Directly in the gorge of the ravine, where we may see the partially wooded banks receding as they ascend from the base to the centre, and then bellying over from the centre to the summit, there is a fine chalybeate spring, surmounted by a dome of hewn stone. It was discovered by the miners, when in quest of the mineral which they did not and could not discover, and forms one of the finest specimens of a true Artesian well which I have anywhere seen. They had bored to a considerable depth, when, on withdrawing the kind of augre used for the purpose, a bolt of water, which occupied the whole diameter of the bore, came rushing after like the jet of a fountain, and the work was prosecuted no further; for, as steam-engines were not yet invented, no pit could

have been wrought with so large a stream issuing into it; and as the volume was evidently restricted by the size of the bore, it was impossible to say how much greater a stream the source might have supplied. The spring still continues to flow towards the sea between its double row of cresses, at the rate of about a hogshead per minute—a rate considerably diminished, it is said, from its earlier volume, by some obstruction in the bore. The waters are not strongly tinctured—a consequence, perhaps, of their great abundance; but we may see every pebble and stalk in their course enveloped by a ferruginous coagulum, resembling burnt sienna, that has probably been disengaged from the dark red sandstone below, which is known to owe its colour to the oxide of iron. A Greek poet would probably have described the incident as the birth of the Naiad; in the north, however, which in an earlier age had also its Naiads, though, like the fish of the Old Red Sandstone, they have long since become extinct, the recollection of it is merely preserved by tradition, as a curious, though by no means poetical fact, and by the name of the well, which is still known as the well of the *coal-heugh*—the old Scotch name for a coal-pit. Calderwood tells us, in his description of a violent tempest which burst out immediately as his persecutor, James VI., breathed his last, that in the south of Scotland the sea rose high upon the land, and that many "*coal-heughs* were drowned."

There is no science whose value can be adequately estimated by economists and utilitarians of the lower order. Its true quantities cannot be represented by arithmetical figures or monetary tables; for its effects

on mind must be as surely taken into account as its operations on matter, and what it has accomplished for the human intellect as certainly as what it has done for the comforts of society, or the interests of commerce. Who can attach a marketable value to the discoveries of Newton? I need hardly refer to the often-quoted remark of Johnson; the beauty of the language in which it is couched has rendered patent to all the truth which it conveys. "Whatever withdraws us from the power of the senses," says the moralist—"whatever makes the past, the distant, or the future, predominate over the present, advances us in the dignity of thinking beings." And Geology, in a peculiar manner, supplies to the intellect an exercise of this ennobling character. But it has also its cash value. The time and money squandered in Great Britain alone in searching for coal in districts where the well-informed geologist could have at once pronounced the search hopeless, would much more than cover the expense at which geological research has been prosecuted throughout the world. There are few districts in Britain occupied by the secondary deposits, in which, at one time or another, the attempt has not been made. It has been the occasion of enormous expenditure in the south of England among the newer formations, where the coal, if it at all occurs (for we occasionally meet with wide gaps in the scale), must be buried at an unapproachable depth. It led in Scotland—in the northern county of Sutherland—to an unprofitable working for many years of a sulphureous lignite of the inferior Oolite, far above the true Coal Measures. The attempt I have just been

describing was made in a locality as far beneath them. There is the scene of another and more modern attempt in the same district, on the shores of the Moray Frith, in a detached patch of Lias, where a fossilized wood would no doubt be found in considerable abundance, but no continuous vein even of lignite. And it is related by Dr. Anderson of Newburgh, that a fruitless and expensive search after coal has lately been instituted in the Old Red Sandstone beds which traverse Strathearn and the Carse of Gowrie, in the belief that they belong not to the Old, but to the *New* Red Sandstone—a formation which has been successfully perforated in prosecuting a similar search in various parts of England. All these instances—and there are hundreds such—show the economic importance of the study of fossils. The Oolite has its veins of apparent coal on the coast of Yorkshire, and its still more amply developed veins—one of them nearly four feet in thickness—on the eastern coast of Sutherlandshire; the Lias has its coniferous fossils in great abundance, some of them converted into a lignite which can scarce be distinguished from a true coal; and the bituminous masses of the Lower Old Red, and its carbonaceous markings, appear identical, to an unpractised eye, with the impressions on the carboniferous sandstones, and the bituminous masses which they, too, are occasionally found to enclose. Nor does the mineralogical character of its middle beds differ in many cases from that of the lower members of the New Red Sandstone. I have seen the older rock in the north of Scotland as strongly saliferous as any of the newer sandstones, of well-nigh as

bright a brick-red tint, of as friable and mouldering a texture, and variegated as thickly with its specks and streaks of green and buff-colour. But in all these instances there are strongly characterized groups of fossils, which, like the landmarks of the navigator, or the findings of his quadrant, establish the true place of the formations to which they belong. Like the patches of leather, of scarlet, and of blue, which mark the line attached to the deep-sea lead, they show the various depths at which we arrive. The Earls of Sutherland set themselves to establish a coal-work among the chambered univalves of the Oolite, and a vast abundance of its peculiar bivalves. The coal-borers who perforated the Lias near Cromarty passed every day to and from their work over one of the richest deposits of animal remains in the kingdom—a deposit full of the most characteristic fossils; and drove their augre through a thousand belemnites and ammonites of the upper and inferior Lias, and through gryphites and ichthyodorulites innumerable. The sandstones of Strathearn and the Carse of Gowrie yield their plates and scales of the *Holoptychius*, the most abundant fossil of the Upper Old Red; and the shale of the little dell in which the first Earl of Cromarty set his miners to work, contains, as I have said, plates of the *Coccosteus*, and scales of the *Osteolepis*—fossils found only in the Lower Old Red. Nature in all these localities furnished the index, but men lacked the skill necessary to decipher it.* I may

* There occurs in Mr. Murchison's *Silurian System* a singularly amusing account of one of the most unfortunate of all coal-boring enterprises; the unlucky projector, a Welsh farmer, having set himself to dig for coal in the lowest member of the

mention that, independently of their well-marked organisms, there is a simple test through which the lignites of the newer formations may be distinguished

system, at least six formations beneath the only one at which the object of his search could have been found. Mr. Murchison thus relates the story:—

"At Tin-y-coed I found a credulous farmer ruining himself in excavating a horizontal gallery in search of coal, an ignorant miner being his engineer. The case may serve as a striking example of the *coal-boring* mania in districts which cannot by possibility contain that mineral; and a few words concerning it may, therefore, prove a salutary warning to those who speculate for coal in the Silurian Rocks. The farm-house of Tin-y-coed is situated on the sloping sides of a hill of trap, which throw off, upon its north-western flank, thin beds of black grauwacke shale, dipping to the west-north-west at a high angle. The colour of the shale, and of the water that flowed down its sides, the pyritous veins, and other vulgar symptoms of coal-bearing strata, had long convinced the farmer that he possessed a large hidden mass of coal, and unfortunately, a small fragment of real anthracite was discovered, which burnt like the best coal. Miners were sent for, and operations commenced. To sink a shaft was impracticable, both from the want of means, and the large volume of water. A slightly-inclined gallery was therefore commenced, the mouth of which was opened at the bottom of the hill, on the side of the little brook which waters the dell. I have already stated, that in many cases, where the intrusive trap throws off the shale, the latter preserves its natural and unaltered condition to within a certain distance of the trap; and so it was at Tin-y-coed, for the level proceeded for 155 feet with little or no obstacle. Mounds of soft black shale attested the rapid progress of the adventurers, when suddenly they came to a 'change of metal.' They were now approaching the nucleus of the little ridge; and the rock they encountered was, as the men informed me, '*as hard as iron*,' viz., of lydianized schist, precisely analogous to that which is exposed naturally in ravines where all the phenomena are laid bare. The deluded people, however, endeavoured to penetrate the hardened mass, but the vast expense of blasting it put a stop to the undertaking, not, however, without a thorough conviction on the part of the farmer, that could he but have got through

from the true coal of the carboniferous system. Coal, though ground into an impalpable powder, retains its deep black colour, and may be used as a black pigment; lignite, on the contrary, when fully levigated, assumes a reddish, or rather umbry hue.

I have said that the waters of the well of the coal-heugh are chalybeate—a probable consequence of their infiltration through the iron oxides of the superior beds of the formation, and their subsequent passage through the deep red strata of the inferior bed. There could be very curious chapters written on mineral springs, in their connection with the formations through which they pass. Smollett's master-piece, honest old Matthew Bramble, became thoroughly disgusted with the Bath waters on discovering that they filtered through an ancient burying-ground belonging to the Abbey, and that much of their peculiar taste and odour might probably be owing to the "rotten bones and mouldering carcasses" through which they were strained. Some of the springs of the Old Red Sandstone have also the church-yard taste, but the bones and carcasses through which they strain are much older than those of the Abbey burying-ground at Bath. The

that hard stuff, he would most surely have been well recompensed, for it was just thereabouts that they began to find '*small veins of coal.*' It has been before shown that portions of anthracite are not unfrequent in the altered shale, where it is in contact with the intrusive rock. And the occurrence of the smallest portion of anthracite is always sufficient to lead the Radnorshire farmer to suppose that he is very near 'El Dorado.' Amid all their failures, I never met with an individual who was really disheartened; a frequent exclamation being, 'Oh, if our squires were only men of *spirit*, we should have as fine coal as any in the world.'" (*Silurian System*, part i., p. 328.)

bitumen of the strongly impregnated rocks and clay-beds of this formation, like the bitumen of the still more strongly impregnated limestones and shales of the Lias, seems to have had rather an animal than vegetable origin. The shales of the Eathic Lias burn like turf soaked in oil, and yet they hardly contain one per cent. of vegetable matter. In a single cubic inch, however, I have counted about eighty molluscous organisms, mostly ammonites, and minute striated scallops; and the mass, when struck with the hammer, still yields the heavy odour of animal matter in a state of decay. The lower fish-beds of the Old Red are, in some localities, scarcely less bituminous. The fossil scales and plates which they enclose burn at the candle: they contain small cavities filled with a strongly-scented semi-fluid bitumen, as adhesive as tar, and as inflammable; and for many square miles together the bed is composed almost exclusively of a dark-coloured semi-calcareous, semi-aluminous schist, scarcely less fetid, from the great quantity of this substance which it contains, than the swine-stones of England. Its vegetable remains bear but a small proportion to its animal organisms; and from huge accumulations of these last decomposing amid the mud of a still sea, little disturbed by tempests or currents, and then suddenly interred by some widely-spread catastrophe, to ferment and consolidate under vast beds of sand and conglomerate, the bitumen*

* "In the slaty schists of Seefeld, in the Tyrol," say Messrs. Sedgwick and Murchison, "there is such an abundance of a similar bitumen, that it is largely extracted for medicinal purposes.' (*Geol. Trans. for* 1829, p. 134.)

seems to have been elaborated. These bituminous schists, largely charged with sulphuret of iron, run far into the interior, along the flanks of the gigantic Ben Wevis, and through the exquisitely pastoral valley of Strathpeffer. The higher hills which rise over the valley are formed mostly of the great conglomerate—Knockferril, with its vitrified fort—the wooded and precipitous ridge over Brahan—and the middle eminences of the gigantic mountain on the north; but the bottom and the lower slopes of the valley are occupied by the bituminous and sulphureous schists of the fish-bed, and in these, largely impregnated with the peculiar ingredients of the formation, the famous medicinal springs of the Strath have their rise. They contain, as shown by chemical analysis, the sulphates of soda, of lime, of magnesia, common salt, and above all, sulphureted hydrogen gas—elements which masses of sea-mud charged with animal matter would yield as readily to the chemist as the medicinal springs of Strathpeffer. Is it not a curious reflection, that the commercial greatness of Britain in the present day should be closely connected with the towering and thickly-spread forests of arboraceous ferns and gigantic reeds—vegetables of strange form and uncouth names—which flourished and decayed on its surface age after age during the vastly-extended term of the carboniferous period, ere the mountains were yet upheaved, and when there was as yet no man to till the ground? Is it not a reflection equally curious, that the invalids of the present summer should be drinking health, amid the recesses of Strathpeffer, from the still more ancient mineral and animal debris of the

lower ocean of the Old Red Sandstone, strangely elaborated for vast but unreckoned periods in the bowels of the earth? The fact may remind us of one of the specifics of a now obsolete school of medicine, which flourished in this country about two centuries ago, and which included in its *materia medica* portions of the human frame. Among these was the flesh of Egyptian mummies, impregnated with the embalming drugs—the dried muscles and sinews of human creatures who had walked in the streets of Thebes or of Luxor three thousand years ago.

The commoner mineral springs of the formation, as might be anticipated from the very general diffusion of the oxide to which it owes its colour, are chalybeate. There are districts in Easter Ross and the Black Isle in which the traveller scarcely sees a runnel by the way-side that is not half-choked up by its fox-coloured coagulum of oxide. Two of the most strongly-impregnated chalybeates with which I am acquainted gush out of a sandstone-bed, a few yards apart, among the woods of Tarbat House, on the northern shore of the Frith of Cromarty. They splash among the pebbles with a half-gurgling, half-tinkling sound, in a solitary, but not unpleasing recess, darkened by alders and willows; and their waters, after uniting in the same runnel, form a little melancholy-looking *lochan*, matted over with weeds, and edged with flags and rushes, and which swarms in early summer with the young of the frog in its tadpole state, and in the after months with the black water-beetle and the newt. The circumstance is a somewhat curious one, as the presence of iron as an oxide has been held

so unfavourable to both animal and vegetable life, that the supposed poverty of the Old Red Sandstone in fossil remains has been attributed to its almost universal diffusion at the period the deposition was taking place. Were the system as poor as has been alleged, however, it might be questioned, on the strength of a fact such as this, whether the iron militated so much against the living existences of the formation, as against the preservation of their remains when dead.

Some of the springs which issue from the ichthyolite beds along the shores of the Moray Frith are largely charged, not with iron, like the well of the coal-heugh, or the springs of Tarbat House, nor yet with hydrogen and soda, like the spa of Strathpeffer, but with carbonate of lime. When employed for domestic purposes, they choke up, in a few years, with a stony deposition, the spouts of tea-kettles. On a similar principle, they plug up their older channels, and then burst out in new ones; nor is it uncommon to find among the cliffs little hollow recesses, long since divested of their waters by this process, that are still thickly surrounded by coral-like incrustations of moss and lichens, grass and nettle stalks, and roofed with marble-like stalactites. I am acquainted with at least one of these springs of very considerable volume, and dedicated of old to an obscure Roman Catholic saint, whose name it still bears (St. Bennet), which presents phenomena not unworthy the attention of the young geologist. It comes gushing from out the ichthyolite bed, where the latter extends, in the neighbourhood of Cromarty, along the shores of the Moray Frith; and after depositing in a stagnant

morass an accumulation of a greyish-coloured and partially consolidated travertin, escapes by two openings to the shore, where it is absorbed among the sand and gravel. A storm about three years ago swept the beach several feet beneath its ordinary level, and two little moles of conglomerate and sandstone, the work of the spring, were found to occupy the two openings. Each had its fossils—comminuted sea shells, and stalks of hardened moss; and in one of the moles I found embedded a few of the vertebral joints of a sheep. It was a recent formation on a small scale, bound together by a calcareous cement furnished by the fish-beds of the inferior Old Red Sandstone, and composed of sand and pebbles, mostly from the granitic gneiss of the neighbouring hill, and organisms, vegetable and animal, from both the land and the sea.

The Old Red Sandstone of Scotland has been extensively employed for the purposes of the architect, and its limstones occasionally applied to those of the agriculturist. As might be anticipated in reference to a deposit so widely spread, the quality of both its sandstones and its lime is found to vary exceedingly in even the same beds when examined in different localities. Its inferior conglomerate, for instance, in the neighbourhood of Cromarty, weathers so rapidly, that a fence built of stones furnished by it little more than half a century ago, has mouldered in some places into a mere grass-covered mound. The same bed in the neighbourhood of Inverness is composed of a stone nearly as hard and quite as durable as granite, and which has been employed in paving the streets of the place—a purpose which it serves as well as any of the

igneous or primary rocks could have done. At Redcastle, on the northern shore of the Frith of Beauly, the same conglomerate assumes an intermediate character, and forms, though coarse, an excellent building-stone, which, in some of the older ruins of the district, presents the marks of the tool as sharply indented as when under the hands of the workman. Some of the sandstone beds of the system are strongly saliferous; and these, however coherent they may appear, never resist the weather until first divested of their salt. The main ichthyolite bed on the northern shore of the Moray Frith is overlaid by a thick deposit of a finely-tinted yellow sandstone of this character, which, unlike most sandstones of a mouldering quality, resists the frosts and storms of winter, and wastes only when the weather becomes warm and dry. A few days of sunshine affect it more than whole months of high winds and showers. The heat crystallizes at the surface the salt which it contains; the crystals, acting as wedges, throw off minute particles of the stone; and thus, mechanically at least, the degrading process is the same as that to which sandstones of a different but equally inferior quality are exposed during severe frosts. In the course of years, however, this sandstone, when employed in building, loses its salt; crust after crust is formed on the surface, and either forced off by the crystals underneath, or washed away by the rains; and then the stone ceases to waste, and gathers on its weathered inequalities a protecting mantle of lichens.* The

* When left to time the process is a tedious one, and, ere its accomplishment, the beauty of the masonry is always in some

most valuable quarries in the Old Red System of Scotland yet discovered, are the flagstone quarries of Caithness and Carmylie. The former have been opened in the middle schists of the lower or Tilestone formation of the system; the latter, as I have had occasion to remark oftener than once, in the Cornstone or middle formation. The quarries of both Carmylie and Caithness employ hundreds of workmen, and their flagstones form an article of commerce. The best building-stone of the north of Scotland—best both for beauty and durability—is a pure Quartzose Sandstone furnished by the upper beds of the system. These are extensively quarried in Moray, near the village of Burghead, and exported to all parts of the kingdom. The famous obelisk of Forres, so interesting to the antiquary—which has been described by some writers as formed of a species of stone unknown in the district, and which, according to a popular tradition, was transported from the Continent, is evidently composed of this Quartzose Sandstone, and must have been dug out of one of the neighbouring quarries. And so coherent is its texture, that the storms of perhaps ten centuries have failed to obliterate its rude but impressive sculptures.

degree destroyed. The following passage, from a popular work, points out a mode by which it might possibly be anticipated, and the waste of surface prevented: "A hall of which the walls were constantly damp, though every means were employed to keep them dry, was about to be pulled down, when M. Schmithall recommended, as a last resource, that the walls should be washed with sulphuric acid (vitriol). It was done, and the deliquescent salts being decomposed by acid, the walls dried, and the hall was afterwards free from dampness." (*Recreations in Science.*)

The limestones of both the upper and lower formations of the system have been wrought in Moray with tolerable success. In both, however, they contain a considerable per-centage of siliceous and argillaceous earth. The system, though occupying an intermediate place between two metalliferous deposits—the grauwacke and the carboniferous limestone—has not been found to contain workable veins anywhere in Britain, and in Scotland no metallic veins of any kind, with the exception of here and there a few slender threads of ironstone, and here and there a few detached crystals of galena. Its wealth consists exclusively in building and paving-stone, and in lime. Some of the richest tracts of corn-land in the kingdom rest on the Old Red Sandstone—the agricultural valley of Strathmore, for instance, and the fertile plains of Easter-Ross: Caithness has also its deep corn-bearing soils, and Moray has been well known for centuries as the granary of Scotland. But in all these localities the fertility seems derived rather from an intervening subsoil of tenacious diluvial clay, than from the rocks of the system. Wherever the clay is wanting the soil is barren. In the moor of the Milbuy—a tract about fifty square miles in extent, and lying within an hour's walk of the Friths of Cromarty and Beauly—a thin covering of soil rests on the sandstones of the lower formation. And so extreme is the barrenness of this moor, that notwithstanding the advantages of its semi-insular situation, it was suffered to lie as an unclaimed common until about twenty-five years ago, when it was parcelled out among the neighbouring proprietors.

CHAPTER XI.

Geological Physiognomy—Scenery of the Primary Formations; Gneiss, Mica Schist, Quartz Rock—Of the Secondary; the Chalk Formations, the Oolite, the New Red Sandstone, the Coal Measures—Scenery in the neighbourhood of Edinburgh—Aspect of the Trap Rocks—the Disturbing and Denuding Agencies—Distinctive Features of the Old Red Sandstone—Of the great Conglomerate—Of the Ichthyolite Beds—The Burn of Eathie—The Upper Old Red Sandstones—Scene in Moray.

PHYSIOGNOMY is no idle or doubtful science in connection with Geology. The physiognomy of a country indicates almost invariably its geological character. There is scarce a rock among the more ancient groups that does not affect its peculiar form of hill and valley. Each has its style of landscape; and as the vegetation of a district depends often on the nature of the underlying deposits, not only are the main outlines regulated by the mineralogy of the formations which they define, but also in many cases the manner in which these outlines are filled up. The colouring of the landscape is well-nigh as intimately connected with its Geology as the drawing. The traveller passes through a mountainous region of gneiss.

The hills, which, though bulky, are shapeless, raise their huge backs so high over the brown dreary moors which, unvaried by precipice or ravine, stretch away for miles from their feet, that even amid the heats of midsummer the snow gleams in streaks and patches from their summits. And yet so vast is their extent of base, and their tops so truncated, that they seem but half-finished hills notwithstanding—hills interdicted somehow in the forming, and the work stopped ere the upper storeys had been added. He pursues his journey, and enters a district of micaceous schist. The hills are no longer truncated or the moors unbroken; the heavy ground-swell of the former landscape has become a tempestuous sea, agitated by powerful winds and conflicting tides. The picturesque and somewhat fantastic outline is composed of high sharp peaks, bold craggy domes, steep broken acclivities, and deeply serrated ridges; and the higher hills seem as if set round with a framework of props and buttresses, that stretch out on every side like the roots of an ancient oak. He passes on, and the landscape varies: the surrounding hills, though lofty, pyramidal, and abrupt, are less rugged than before; and the ravines, though still deep and narrow, are walled by ridges no longer serrated and angular, but comparatively rectilinear and smooth. But the vegetation is even more scanty than formerly; the steeper slopes are covered with streams of debris, on which scarce a moss or lichen finds root; and the conoidal hills, bare of soil from their summits half-way down, seem so many naked skeletons, that speak of the decay and death of nature. All is solitude and sterility. The territory

is one of Quartz Rock. Still the traveller passes on: the mountains sink into low swellings; long rectilinear ridges run out towards the distant sea, and terminate in bluff precipitous headlands. The valleys, soft and pastoral, widen into plains, or incline in long-drawn slopes of gentlest declivity. The streams, hitherto so headlong and broken, linger beside their banks, and then widen into friths and estuaries. The deep soil is covered by a thick mantle of vegetation—by forest trees of largest growth, and rich fields of corn; and the solitude of the mountains has given place to a busy population. He has left behind him the primary regions, and entered on one of the secondary districts.

And these less rugged formations have also their respective styles—marred and obliterated often by the Plutonic agency, which imparts to them in some instances its own character, and in some an intermediate one, but in general distinctly marked and easily recognised. The Chalk presents its long inland lines of apparent coast, that send out their rounded headlands, cape beyond cape, into the wooded or corn-covered plains below. Here and there, there juts up at the base of the escarpment a white obelisk-like stack; here and there, there opens into the interior a narrow grassy bay, in which noble beeches have cast anchor. There are valleys without streams; and the landscape atop is a scene of arid and uneven downs, that seem to rise and fall like the sea after a storm. We pass on to the Oolite: the slopes are more gentle, the lines of rising ground less continuous and less coast-like, the valleys have their rivulets, and the un-

dulating surface is covered by a richer vegetation. We enter on a district of New Red Sandstone. Deep narrow ravines intersect elevated platforms. There are lines of low precipices so perpendicular and so red that they seem as if walled over with new brick; and here and there, amid the speckled and mouldering sandstones that gather no covering of lichen, there stands up a huge altar-like mass of lime, mossy and grey, as if it represented a remoter antiquity than the rocks around it. The Coal Measures present often the appearance of vast lakes frozen over during a high wind, partially broken afterwards by a sudden thaw, and then frozen again. Their shores stand up around them in the form of ridges and mountain-chains of the older rocks; and their surfaces are grooved into flat valleys and long lines of elevation. Take as an instance the scenery about Edinburgh. The Ochil Hills and the Grampians form the distant shores of the seeming lake or basin on the one side, the range of the Lammermuirs and the Pentland group on the other; the space between is ridged and furrowed in long lines, that run in nearly the same direction from north-east to south-west, as if, when the binding frost was first setting in, the wind had blown from off the northern or southern shore.

But whence these abrupt precipitous hills that stud the landscape, and form, in the immediate neighbourhood of the city, its more striking features? They belong—to return to the illustration of the twice-frozen lake—to the middle period of thaw, when the ice broke up; and, as they are composed chiefly of matter ejected from the abyss, might have characterized

equally any of the other formations. Their very striking forms, however, illustrate happily the operations of the great agencies on which, in the secondary and transition deposits, all the peculiarities of scenery depend. The molten matter from beneath seems to have been injected, in the first instance, through rents and fissures among the carboniferous shales and sandstones of the district, where it lay cooling in its subterranean matrices, in beds and dikes, like metal in the moulds of the founder; and the places which it occupied must have been indicated on the surface but by curves and swellings of the strata. The denuding power then came into operation in the form of tides and currents, and ground down the superincumbent rocks. The injected masses, now cooled and hardened, were laid bare; and the softer framework of the moulds in which they had been cast was washed from their summits and sides, except where long ridges remained attached to them in the lines of the current, as if to indicate the direction in which they had broken its force. Every larger stone in a water-course, after the torrent fed by a thunder-shower has just subsided, shows, on the same principle, its trail of sand and shingle piled up behind it. The outlines of the landscape were modified yet further by the yielding character of the basement of sandstone or shale on which the Plutonic beds so often rest. The basement crumbled away as the tides and waves broke against it. The injected beds above, undermined in the process, and with a vertical cleavage, induced by their columnar tendency, fell down in masses that left a front perpendicular as a wall. Each bed came thus to present its

own upright line of precipice; and hence—when they rise bed above bed, as often occurs—the stair-like outline of hill to which the trap-rocks owe their name; hence the outline of the Dalmahoy Crags, for instance, and of the southern and western front of Salisbury Crags.

In all the sedimentary formations the peculiarities of scenery depend on three circumstances—on the Plutonic agencies, the denuding agencies, and the manner and proportions in which the harder and softer beds of the deposits on which these operated alternate with one another. There is an union of the active and the passive in the formation of landscape; that which disturbs and grinds down, and that which, according to its texture and composition, affects, if I may so speak, a peculiar style of being ground down and disturbed; and it is in the passive circumstances that the peculiarities chiefly originate. Hence it is that the scenery of the Chalk differs from the scenery of the Oolite, and both from that of the Coal Measures. The Old Red Sandstone has also its peculiarities of prospect, which vary according to its formations, and the amount and character of the disturbing and denuding agencies to which these have been exposed. Instead, however, of crowding its various, and, in some instances, dissimilar features into one landscape, I shall introduce to the reader a few of its more striking and characteristic scenes, as exhibited in various localities, and by different deposits, beginning first with its conglomerate base.

The great antiquity of this deposit is unequivocally indicated by the manner in which we find it caping,

far in the interior, in insulated beds and patches, some of our loftier hills, or, in some instances, wrapping them round, as with a caul, from base to summit. It mixes largely, in our northern districts, with the mountain scenery of the country, and imparts strength and boldness of outline to every landscape in which it occurs. Its island-like patches affect generally a bluff parabolic or conical outline; its loftier hills present rounded dome-like summits, which sink to the plain on the one hand in steep, slightly concave lines, and on the other in lines decidedly convex, and a little less steep. The mountain of boldest outline in the line of the Caledonian Valley (Mealforvony), is composed externally of this rock. Except where covered by the diluvium, it seems little friendly to vegetation. Its higher summits are well-nigh as bare as those of the primary rocks; and when a public road crosses its lower ridges, the traveller generally finds that there is no paving process necessary to procure a hardened surface, for his wheels rattle over the pebbles embedded in the rock. On the sea-coast, in several localities, the deposit presents striking peculiarities of outline. The bluff and rounded precipices stand out in vast masses, that affect the mural form, and present few of the minuter angularities of the primary rocks. Here and there a square buttress of huge proportions leans against the front of some low-browed crag, that seems little to need any such support, and casts a length of shadow athwart its face. There opens along the base of the rock a line of rounded shallow caves, or what seem rather the openings of caves not yet dug, and which testify of a period when the sea stood

about thirty feet higher on our coasts than at present. A multitude of stacks and tabular masses lie grouped in front, perforated often by squat heavy arches; and stacks, caverns, buttresses, crags, and arches, are all alike mottled over by the thickly-set and variously-coloured pebbles. There is a tract of scenery of this strangely-marked character in the neighbourhood of Dunottar, and two other similar tracts in the far north, where the hill of Nigg, in Ross-shire, declines towards the Lias deposit in the Bay of Shandwick, and where, in the vicinity of Inverness, a line of bold precipitous coast runs between the pyramidal wooded eminence which occupies the south-eastern corner of Ross, and the tower-like headlands that guard the entrance ot the Bay of Munlochy. In the latter tract, however, the conglomerate is much less cavernous than in the other two.

The sea-coast of St. Vigeans, in Forfarshire, has been long celebrated for its romantic scenery and its caves; and though it belongs rather to the conglomerate base of the upper formation than to the great conglomerate base of the lower, it is marked, from the nature of the materials—materials common to both—by features indistinguishable from those which characterize the sea-coasts of the older deposit. Its wall of precipices averages from a hundred to a hundred and eighty feet in height—no very great matter compared with some of our northern lines, but the cliffs make up for their want of altitude by their bold and picturesque combinations of form; and I scarce know where a long summer's day could well be passed more agreeably than among their wild and solitary recesses.

The incessant lashings of the sea have ground them down into shapes the most fantastic. Huge stacks that stand up from amid the breakers, are here and there perforated by round heavy-browed arches, and cast the morning shadows inland athwart the cavern-hollowed precipices behind. The never-ceasing echoes reply, in long and gloomy caves, to the wild tones of the sea. Here a bluff promontory projects into the deep-green water, and the white foam, in times of tempest, dashes up a hundred feet against its face. There a narrow strip of vegetation, spangled with wild flowers, intervenes between the beach and the foot of the cliffs that sweep along the bottom of some semicircular bay; but we see, from the rounded caves by which they are studded, and the polish which has blunted their lower angularities, that at some early period the breakers must have dashed for ages against their bases. The *Gaylet Pot*, a place of interest, from its very striking appearance, to more than geologists, is connected with one of the deep-sea promontories. We see an oblong hollow in the centre of a corn-field, that borders on the cliffs. It deepens as we approach it, and on reaching the edge we find ourselves standing on the verge of a precipice about a hundred and fifty feet in depth, and see the waves dashing along the bottom. On descending by a somewhat precarious path, we find that a long tunnel-like cavern communicates with the sea, and mark, through the deep gloom of the passage, the sunlight playing beyond; and now and then a white sail passing the opening, as if flitting across the field of a telescope. The *Gaylet Pot* seems originally to have been merely a deep straight cave,

hollowed in the line of a fault by the waves; and it owes evidently its present appearance to the falling in of the roof for about a hundred yards, at its inner extremity.

We pass from the conglomerate to the middle and upper beds of the lower formation, and find scenery of a different character in the districts in which they prevail. The aspect is less bold and rugged, and affects often long horizontal lines, that stretch away, without rise or depression, amid the surrounding inequalities of the landscape for miles and leagues, and that decline to either side, like roofs of what the architect would term a low pitch. The ridge of the Leys in the eastern opening of the Caledonian Valley, so rectilinear in its outline, and so sloping in its sides, presents a good illustration of this peculiarity. The rectilinear ridge which runs from the Southern Sutor of Cromarty far into the interior of the country, and which has been compared in a former chapter to the shaft of a spear, furnishes another illustration equally apt.* Where the sloping sides of these roof-like

* The valleys which separate these ridges form often spacious friths and bays, the frequent occurrence of which in the Old Red Sandstone constitutes, in some localities, one of the characteristics of the system. Mark in a map of the north of Scotland, how closely friths and estuaries lie crowded together between the counties of Sutherland and Inverness. In a line of coast little more than forty miles in extent, there occur four arms of the sea—the Friths of Cromarty, Beauly, and Dornoch, and the Bay of Munlochy. The Frith of Tay and the Basin of Montrose are also semi-marine valleys of the Old Red Sandstone. Two of the finest harbours in Britain, or the world, belong to it—Milford Haven in South Wales, and the Bay of Cromarty.

ridges decline, as in the latter instance, towards an exposed sea-coast, we find the slope terminating often in an abrupt line of rock dug out by the waves. It is thus a roof set on walls, and furnished with eaves. A ditch just finished by the labourer presents regularly sloping sides; but the little stream that comes running through gradually widens its bed by digging furrows into the slopes, the undermined masses fall in and are swept away, and in the course of a few months the sides are no longer sloping, but abrupt. And such, on a great scale, has been the process through which coast-lines that were originally paved slopes have become walls of precipices. The waves cut first through the outer strata; and every stratum thus divided comes to present two faces—a perpendicular face in the newly-formed line of precipice, and another horizontal face lying parallel to it, along the shore. One half the severed stratum seems as if rising out of the sea, the other half as if descending from the hill: the geologist who walks along the beach finds the various beds presented in duplicate—a hill-bed on the one side, and a sea-bed on the other. There occurs a very interesting instance of this arrangement in the bold line of coast on the northern shore of the Moray Frith, so often alluded to in a previous chapter, as extending between the Southern Sutor and the Hill of Eathie; and which forms the wall of a portion of the roof-like ridge last described. The sea first broke in a long line through strata of red and grey shale, next through a thick bed of pale-yellow. stone, then through a continuous bed of stratified clays and nodular limestone, and last of all

through a bed, thicker than any of the others, of indurated red sandstone. The line of cliffs formed in this way rises abruptly for about a hundred yards on the one hand; the shore stretches out for more than double the same space on the other; on both sides the beds exactly correspond; and to ascend in the line of the strata from the foot of the cliffs, we have either to climb the hill, or to pass downwards at low ebb to the edge of the sea. The section is of interest, not only from the numerous organisms, animal and vegetable, which its ichthyolite beds contain, but from the illustration which it also furnishes of denudation to a vast extent from causes still in active operation. A line of precipices a hundred yards in height, and more than two miles in length, has been dug out of the slope by the slow wear of the waves, in the unreckoned course of that period during which the present sea was bounded in this locality by the existing line of coast. (See Frontispiece, sect. 3.)

I know not a more instructive walk for the young geologist than that furnished by the two miles of shore along which this section extends. Years of examination and inquiry would fail to exhaust it. It presents us, I have said, with the numerous organisms of the Lower Old Red Sandstone; it presents us also, towards its western extremity, with the still more numerous organisms of the Lower and Upper Lias; nor are the inflections and faults which its strata exhibit less instructive than its fossils or its vast denuded hollow. I have climbed along its wall of cliffs during the height of a tempestuous winter tide, when waves of huge volume, that had begun to gather strength

under the night of the Northern Ocean, were bursting and foaming below; and as the harder pebbles, uplifted by the surge, rolled by thousands and tens of thousands along the rocky bottom, and the work of denudation went on, I have thought of the remote past, when the same agents had first begun to grind down the upper strata, whose broken edges now projected high over my head on the one hand, and lay buried far under the waves at my feet on the other. Almost all mountain chains present their abrupter escarpments to the sea, though separated from it in many instances by hundreds of miles—a consequence, it is probable, of a similar course of denudation, ere they had attained their present altitude, or the plains at their feet had been elevated over the level of the ocean. Had a rise of a hundred feet taken place in this northern district in the days of Cæsar, the whole upper part of the Moray Frith would have been laid dry, and it would now have seemed as inexplicable that this roof-like ridge should present so rugged a line of wall to the distant sea, as that the Western Ghauts of India should invariably turn their steepest declivities, to the basin of the Indian Ocean, or that from the arctic circle to the southern extremity of Patagonia the huge mountain-chain of America should elevate its dizzy precipices in the line of the Pacific.

Let us take another view of this section. It stretches between two of the granitic knobs or wedges to which I have had such frequent occasion to refer —the Southern Sutor of Cromarty, and the Hill of Eathie; and the edges of the strata somewhat remind one of the edges of a bundle of deals laid flat-

ways on two stones, and bent towards the middle by their own weight. But their more brittle character is shown by the manner in which their ends are broken and uptilted against the granitic knobs on which they seem to rest; and towards the western knob the whole bundle has been broken across from below, and the opening occasioned by the fracture forms a deep savage ravine, skirted by precipices, that runs far into the interior, and exhibits the lower portion of the system to well-nigh its base. Will the reader spend a very few minutes in exploring the solitary recesses of this rocky trench—it matters not whether as a scene-hunter or a geologist? We pass onwards along the beach through the middle line of the denuded hollow. The natural rampart that rises on the right ascends towards the uplands in steep slopes, lined horizontally by sheep walks, and fretted by mossy knolls and churchyard-like ridges—or juts out into abrupt and weathered crags, crusted with lichens and festooned with ivy—or recedes into bosky hollows, roughened by the sloe-thorn, the wild-rose, and the juniper; on the left the wide extent of the Moray Frith stretches out to the dim horizon, with its vein-like currents, and its undulating lines of coast; while before us we see, far in the distance, the blue vista of the Great Valley, with its double wall of jagged and serrated hills, and directly in the opening, the grey diminished spires of Inverness. We reach a brown mossy stream, of just volume enough to sweep away the pebbles and shells that have been strewed in its course by the last tide; and see, on turning a sudden angle, the precipices cleft to their base by the ravine

that has yielded its waters a passage from the interior.

We enter along the bed of the stream. A line of mural precipices rises on either hand—here advancing in ponderous overhanging buttresses, there receding into deep damp recesses, tapestried with ivy and darkened with birch and hazel. A powerful spring, charged with lime, comes pouring by a hundred different threads over the rounded brow of a beetling crag, and the decaying vegetation around it is hardening into stone. The cliffs vary their outline at every step, as if assuming in succession all the various combinations of form that constitute the wild and the picturesque; and the pale hues of the stone seem, when brightened by the sun, the very tints a painter would choose to heighten the effect of his shades, or to contrast most delicately with the luxuriant profusion of bushes and flowers that wave over the higher shelves and crannies. A colony of swallows have built from time immemorial under the overhanging strata of one of the loftier precipices; the fox and badger harbour in the clefts of the steeper and more inaccessible banks. As we proceed, the dell becomes wilder and more deeply wooded; the stream frets and toils at our feet—here leaping over an opposing ridge—there struggling in a pool—yonder escaping to the light from under some broken fragment of cliff. There is a richer profusion of flowers, a thicker mantling of ivy and honeysuckle; and after passing a semicircular inflection of the bank, that waves from base to summit with birch, hazel, and hawthorn, we find the passage shut up by a perpen-

dicular wall of rock about thirty feet in height, over which the stream precipitates itself, in a slender column of foam, into a dark mossy basin. The long arms of an intermingled clump of birches and hazels stretch half-way across, tripling with their shade the apparent depth of the pool, and heightening in an equal ratio the white flicker of the cascade, and the effect of the bright patches of foam which, flung from the rock, incessantly revolve on the eddy.

Mark now the geology of the ravine. For about half-way from where it opens to the shore to where the path is obstructed by the deep mossy pool and the cascade, its precipitous sides consist of three bars or storeys. There is first, reckoning from the stream upwards, a broad bar of pale red; then a broad bar of pale lead colour; last and highest, a broad bar of pale yellow; and above all, there rises a steep green slope, that continues its ascent till it gains the top of the ridge. The middle lead-coloured bar is an ichthyolite bed, a place of sepulture among the rocks, where the dead lie by myriads. The yellow bar above is a thick bed of saliferous sandstone. We may see the projections on which the sun has beat most powerfully covered with a white crust of salt; and it may be deemed worthy of remark, in connection with the circumstance, that its shelves and crannies are richer in vegetation than those of the other bars. The pale-red bar below is composed of a coarser and harder sandstone, which forms an upper moiety of the arenaceous portion of the great conglomerate. Now mark, further, that on reaching a midway point between the beach and the cascade, this triple-barred line of pre-

cipices abruptly terminates, and a line of precipices of coarse conglomerate as abruptly begins. I occasionally pass a continuous wall built at two different periods, and composed of two different kinds of materials: the one-half of it is formed of white sandstone, the other half of a dark-coloured basalt; and the place where the sandstone ends and the basalt begins is marked by a vertical line, on the one side of which all is dark coloured, while all is of a light colour on the other. Equally marked and abrupt is the vertical line which separates the triple-barred from the conglomerate cliffs of the ravine of Eathie. The ravine itself may be described as a fault in the strata; but here is a fault, lying at right angles with it, on a much larger scale: the great conglomerate on which the triple bars rest has been cast up at least two hundred feet, and placed side by side with them. And yet the surface above bears no trace of the catastrophe. Denuding agencies of even greater power than those which have hollowed out the cliffs of the neighbouring coast, or whose operations have been prolonged through periods of even more extended duration, have ground down the projected line of the upheaved mass to the level of the undisturbed masses beside it. Now, mark further, as we ascend the ravine, that the grand cause of the disturbance appears to illustrate, as it were, and that very happily, the manner in which the fault was originally produced. The precipice over which the stream leaps at one bound into the mossy hollow, is composed of granitic gneiss, and seems evidently to have intruded itself, with much disturbance, among the surrounding conglomerate and sandstones. A few

hundred yards higher up the dell, there is another much loftier precipice of gneiss, round which we find the traces of still greater disturbance; and higher still, yet a third abrupt precipice of the same rock. The gneiss rose, trap-like, in steps, and carried up the sandstone before it in detached squares. Each step has its answering fault immediately over it; and the fault where the triple bars and the conglomerate meet is merely a fault whose step of granitic gneiss stopped short ere it reached the surface. But the accompanying section (see Frontispiece, sect. 4) will better illustrate the geology of this interesting ravine, than it can be illustrated by any written description. I may remark, ere taking leave of it, however, that its conglomerates exhibit a singularly large amount of false stratification at an acute angle with the planes of the real strata, and that a bed of mouldering sandstone near the base of the system may be described, from its fissile character, as a tilestone.*

* There is a natural connection, it is said, between wild scenes and wild legends; and some of the traditions connected with this romantic and solitary dell illustrate the remark. Till a comparatively late period it was known at many a winter fire-side as a favourite haunt of the fairies—the most poetical of all our old tribes of spectres, and at one time one of the most popular. I have conversed with an old woman who, when a very little girl, had seen myriads of them dancing, as the sun was setting, on the further edge of the dell; and with a still older man, who had the temerity to offer one of them a pinch of snuff at the foot of the cascade. Nearly a mile from where the ravine opens to the sea, it assumes a gentler and more pastoral character: the sides, no longer precipitous, descend towards the stream in green sloping banks; and a beaten path which runs between Cromarty and Rosemarkie winds down the one side, and ascends the other. More than sixty years ago, one Donald Calder, a Cromarty shop-

I know comparatively little of the scenery of the middle or Cornstone formation. Its features in England are bold and striking; in Scotland, of a tamer and more various character. The Den of Balrud-

keeper, was journeying by this path shortly after nightfall. The moon, at full, had just risen; but there was a silvery mist sleeping on the lower grounds, that obscured her light; and the dell, in all its extent, was so overcharged by the vapour, that it seemed an immense overflooded river winding through the landscape. Donald had reached its farther edge, and could hear the rush of the stream from the deep obscurity of the abyss below, when there rose from the opposite side a strain of the most delightful music he had ever heard. He stayed and listened. The words of a song, of such simple beauty that they seemed without effort to stamp themselves on his memory, came wafted in the music; and the chorus, in which a thousand tiny voices seemed to join, was a familiar address to himself—"Hey, Donald Calder; ho, Donald Calder." "There are nane of my Navity acquaintance," thought Donald, "who sing like that. Wha can it be?" He descended into the cloud; but in passing the little stream the music ceased; and on reaching the spot on which the singer had seemed stationed, he saw only a bare bank sinking into a solitary moor, unvaried by either bush or hollow in which the musician might have lain concealed. He had hardly time, however, to estimate the marvels of the case, when the music again struck up, but on the opposite side of the dell, and apparently from the very knoll on which he had so recently listened to it. The conviction that it could not be other than supernatural overpowered him; and he hurried homewards under the influence of a terror so extreme that, unfortunately for our knowledge of fairy literature, it had the effect of obliterating from his memory every part of the song except the chorus. The sun rose as he reached Cromarty; and he found that, instead of having lingered at the edge of the dell for only a few minutes—and the time had seemed no longer—he had spent beside it the greater part of the night.

The fairies have deserted the Burn of Eathie; but we have proof quite as conclusive as the nature of the case admits, that when they ceased to be seen there it would have been vain to

dery is a sweet wooded dell, marked by no characteristic peculiarities. Many of the seeming peculiarities of the formation in Forfarshire, as in Fife, may be traced to the disturbing trap. The appearance exhibited is that of uneven plains, that rise and fall in long undulating ridges—an appearance which any other member of the system might have presented. We find the upper formation associated with scenery of great though often wild beauty; and nowhere is this

have looked for them anywhere else. There is a cluster of turf-built cottages grouped on the southern side of the ravine; a few scattered knolls and a long partially wooded hollow, that seems a sort of covered way leading to the recesses of the dell, interpose between them and the nearer edge; and the hill rises behind. On a Sabbath morning, nearly sixty years ago, the inmates of this little hamlet had all gone to church, all except a herd-boy and a little girl, his sister, who were lounging beside one of the cottages; when just as the shadow of the garden-dial had fallen on the line of noon, they saw a long cavalcade ascending out of the ravine through the wooded hollow. It winded among the knolls and bushes; and, turning round the northern gable of the cottage beside which the sole spectators of the scene were stationed, began to ascend the eminence toward the south. The horses were shaggy, diminutive things, speckled dun and grey; the riders, stunted, misgrown, ugly creatures, attired in antique jerkins of plaid, long grey cloaks, and little red caps, from under which their wild uncombed locks shot out over their cheeks and foreheads. The boy and his sister stood gazing in utter dismay and astonishment, as rider after rider, each one more uncouth and dwarfish than the one that had preceded it, passed the cottage and disappeared among the brushwood, which at that period covered the hill, until at length the entire rout, except the last rider, who lingered a few yards behind the others, had gone by. "What are ye, little mannie? and where are ye going?" inquired the boy, his curiosity getting the better of his fears and his prudence. "Not of the race of Adam," said the creature, turning for a moment in his saddle; "the People of Peace shall never more be seen in Scotland."

more strikingly the case than in the province of Moray, where it leans against the granitic gneiss of the uplands, and slopes towards the sea in long plains of various fertility—deep and rich, as in the neighbourhood of Elgin, or singularly bleak and unproductive, as in the far-famed "heath near Forres." Let us select the scene where the Findhorn, after hurrying over ridge and shallow amid combinations of rock and wood, wildly picturesque as any the kingdom affords, enters on the lower country, with a course less headlong, through a vast trench scooped in the pale-red sandstone of the upper formation. For miles above the junction of the newer and older rocks the river has been toiling in a narrow and uneven channel, between two upright walls of hard grey gneiss, thickly traversed, in every complexity of pattern, by veins of a light-red, large-grained granite. The gneiss abruptly terminates, but not so the wall of precipices. A lofty front of gneiss is joined to a lofty front of sandstone, like the front walls of two adjoining houses; and the broken and uptilted strata of the softer stone show that the older and harder rocks must have invaded it from below. A little farther down the stream, the strata assume what seems, in a short extent of frontage, a horizontal position, like courses of ashler in a building, but which, when viewed in the range, is found to incline at a low angle towards the distant sea. Here, as in many other localities, the young geologist must guard against the conclusion that the rock is necessarily low in the geological scale, which he finds resting against the gneiss. The gneiss, occupying a very different

place from that on which it was originally formed, has been thrust into close neighbourhood with widely-separated formations. The great conglomerate base of the system rests over it in Orkney, Caithness, Ross, Cromarty, and Inverness; and there is no trace of what should be the intervening grauwacke. The upper formation of the system leans upon it here. We find the Lower Lias uptilted against it at the Hill of Eathie—the great Oolite on the eastern coast of Sutherland; and as the flints and chalk fossils of Banff and Aberdeen are found lying immediately over it in these counties, it is probable that the denuded members of the Cretaceous group once rested upon it there. The fact that a deposit should be found lying in contact with the gneiss, furnishes no argument for the great antiquity or the fundamental character of that deposit; and it were well that the geologist who sets himself to estimate the depth of the Old Red Sandstone, or the succession of its various formations, should keep the circumstance in view. That may be in reality but a small and upper portion of the system which he finds bounded by the gneiss on its under side, and by the diluvium on its upper.

We stand on a wooded eminence, that sinks perpendicularly into the river on the left, in a mural precipice, and descends with a billowy swell into the broad fertile plain in front, as if the uplands were breaking in one vast wave upon the low country. There is a patch of meadow on the opposite side of the stream, shaded by a group of ancient trees, gnarled and mossy, and with half their topmost branches dead

and white as the bones of a skeleton. We look down upon them from an elevation so commanding that their uppermost twigs seem on well-nigh the same level with their interlaced and twisted roots, washed bare on the bank edge by the winter floods. A colony of herons has built from time immemorial among the branches. There are trees so laden with nests that the boughs bend earthwards on every side, like the boughs of orchard-trees in autumn; and the bleached and feathered masses which they bear—the cradles of succeeding generations—glitter grey through the foliage in continuous groups, as if each tree bore on its single head all the wigs of the Court of Session. The solitude is busy with the occupations and enjoyments of instinct. The birds, tall and stately, stand by troops in the shallows, or wade warily, as the fish glance by, to the edge of the current, or rising, with the slow flap of wing and sharp creak peculiar to the tribe, drop suddenly into their nests. The great forest of Darnaway stretches beyond, feathering a thousand knolls, that reflect a colder and greyer tint as they recede and lessen, and present on the horizon a billowy line of blue. The river brawls along under pale-red cliffs, wooded atop. It is through a vast burial-yard that it has cut its way—a field of the dead so ancient that the sepulchres of Thebes and Luxor are but of the present day in comparison—resting-places for the recently departed, whose funerals are but just over. These mouldering strata are charged with remains, scattered and detached as those of a churchyard, but not less entire in their parts—occipital bones, jaws, teeth, spines, scales—the dust and rub-

bish of a departed creation. The cliffs sink as the plain flattens, and green sloping banks of diluvium take their place; but they again rise in the middle distance into an abrupt and lofty promontory, that, stretching like an immense rib athwart the level country, projects far into the stream, and gives an angular inflection to its course. There ascends from the apex a thin blue column of smoke—that of a lime-kiln. That ridge and promontory are composed of the thick limestone band, which, in Moray as in Fife, separates the pale-red from the pale-yellow beds of the Upper Old Red Sandstone; and the flattened tracts on both sides show how much better it has resisted the denuding agencies than either the yellow strata that rest over it, or the pale-red strata which it overlies.

CHAPTER XII.

The two Aspects in which Matter can be viewed; Space and Time—Geological History of the Earlier Periods—The Cambrian System—Its Annelids—The Silurian System—Its Corals, Encrinites, Molluscs, and Trilobites—Its Fish—These of a high Order, and called into Existence apparently by Myriads—Opening Scene in the History of the Old Red Sandstone a Scene of Tempest—Represented by the Great Conglomerate—Red a prevailing Colour among the Ancient Rocks contained in this Deposit—Amazing Abundance of Animal Life—Exemplified by a Scene in the Herring Fishery—Platform of Death—Probable Cause of the Catastrophe which rendered it such.

"THERE are only two different aspects," says Dr. Thomas Brown, "in which matter can be viewed. We may consider it simply as it exists in space, or as it exists in time. As it exists in space we inquire into its composition, or, in other words, endeavour to discover what are the elementary bodies that co-exist in the space which it occupies; as it exists in time, we inquire into its susceptibilities or its powers, or, in other words, endeavour to trace all the various changes which have already passed over it, or of which it may yet become the subject."

Hitherto I have very much restricted myself to the consideration of the Old Red Sandstone as it exists in *space*—to the consideration of it as we now find

it. I shall now attempt presenting it to the reader as it existed in *time*—during the succeeding periods of its formation, and when its existences lived and moved as the denizens of primeval oceans. It is one thing to describe the appearance of a forsaken and desert country, with its wide wastes of unprofitable sand, its broken citadels and temples, its solitary battle-plains, and its gloomy streets of caverned and lonely sepulchres; and quite another to record its history during its days of smiling fields, populous cities, busy trade, and monarchical splendour. We pass from the dead to the living—from the cemetery, with its high piles of mummies and its vast heaps of bones, to the ancient city, full of life and animation in all its streets and dwellings.

Two great geological periods have already come to their close; and the floor of a widely-spread ocean, to which we can affix no limits, and of whose shores or their inhabitants nothing is yet known, is occupied to the depth of many thousand feet by the remains of bygone existences. Of late, the geologist has learned from Murchison to distinguish the rocks of these two periods—the lower as those of the Cambrian, the upper as those of the Silurian group. The lower—representative of the first glimmering twilight of being—of a dawn so feeble that it may seem doubtful whether in reality the gloom had lightened—must still be regarded as a period of uncertainty. Its ripple-marked sandstones, and its half-coherent accumulations of dark-coloured strata, which decompose into mud, show that every one of its many planes must have formed in succession an upper surface of the bottom of the sea; but

it remains for future discoverers to determine regarding the shapes of life that burrowed in its ooze, or careered through the incumbent waters. In one locality it would seem as if a few worms had crawled to the surface, and left their involved and tortuous folds doubtfully impressed on the stone. Some of them resemble miniature cables carelessly coiled; others, furnished with what seem numerous legs, remind us of the existing Nereidina of our sandy shores—those red-blooded, many-legged worms, resembling elongated centipedes, that wriggle with such activity among the mingled mud and water, as we turn over the stones under which they had sheltered. Were creatures such as these the lords of this lower ocean? Did they enter first on the stage, in that great drama of being in which poets and philosophers, monarchs and mighty conquerors, were afterwards to mingle as actors? Does the reader remember that story in the *Arabian Nights* in which the battle of the magicians is described? At an early stage of the combat a little worm creeps over the pavement; at its close two terrible dragons contend in an atmosphere of fire. But even the worms of the Cambrian System can scarce be regarded as established. The evidence respecting their place and their nature must still be held as involved in some such degree of doubt as attaches to the researches of the antiquary, when engaged in tracing what their remains much resemble—the involved sculpturings of some Runic obelisk, weathered by the storms of a thousand winters. There is less of doubt, however, regarding the existences of the upper group of rocks—the Silurian.

The depth of this group, as estimated by Mr. Murchison, is equal to double the height of our highest Scottish mountains; and four distinct platforms of being range in it, the one over the other, like storeys in a building. Life abounded on all these platforms, and in shapes the most wonderful. The peculiar encrinites of the group rose in miniature forests, and spread forth their sentient petals by millions and tens of millions amid the waters; vast ridges of corals, peopled by their innumerable builders—numbers without number—rose high amid the shallows; the chambered shells had become abundant—the simpler testacea still more so; extinct forms of the graptolite or sea-pen existed by myriads; and the formation had a class of creatures in advance of the many-legged annelids of the other. It had its numerous family of trilobites—crustaceans nearly as high in the scale as the common crab—creatures with crescent-shaped heads, and jointed bodies, and wonderfully-constructed eyes, which, like the eyes of the bee and the butterfly, had the cornea cut into facets resembling those of a multiplying-glass. Is the reader acquainted with the form of the common *Chiton* of our shores—the little boat-shaped shell-fish that adheres to stones and rocks like the limpet, but which differs from every variety of limpet, in bearing as its covering a jointed, not a continuous shell? Suppose a chiton with two of its terminal joints cut away, and a single plate of much the same shape and size, but with two eyes near the centre, substituted instead, and the animal, in form at least, would be no longer a chiton, but a trilobite. There are appearances, too, which lead to

the inference that the habits of the two families, though representing different orders of being, may not have been very unlike. The chiton attaches itself to the rock by a muscular sucker or foot, which, extending ventrally along its entire length, resembles that of the slug or the snail, and enables it to crawl like them, but still more slowly, by a succession of adhesions. The locomotive powers of the trilobite seem to have been little superior to those of the chiton. If furnished with legs at all, it must have been with soft rudimentary membranaceous legs, little fitted for walking with; and it seems quite as probable, from the peculiarly-shaped under margin of its shell, formed, like that of the chiton, for adhering to flat surfaces, that, like the slug and the snail, it was unfurnished with legs of any kind, and crept on the abdomen. The vast conglomerations of trilobites for which the Silurian rocks are remarkable, are regarded as further evidence of a sedentary condition. Like *Ostreæ*, *Chitones*, and other sedentary animals, they seemed to have adhered together in vast clusters, trilobite over trilobite, in the hollows of submarine precipices, or on the flat muddy bottom below. And such were the master existences of three of the four Silurian platforms, and of the greater part of the fourth, if, indeed, we may not regard the chambered molluscs, their cotemporaries—creatures with their arms clustered round their heads, and with a nervous system composed of a mere knotted cord—as equally high in the scale. We rise to the topmost layers of the system—to an upper gallery of its highest platform—and find nature mightily in advance.

Another and superior order of existences had sprung into being at the fiat of the Creator—creatures with the brain lodged in the head, and the spinal cord enclosed in a vertebrated column. In the period of the Upper Silurian, fish properly so called, and of very perfect organization, had become denizens of the watery element, and had taken precedence of the crustacean, as, at a period long previous, the crustacean had taken precedence of the annelid. In what form do these, the most ancient beings of their class, appear? As cartilaginous fishes of the higher order. Some of them were furnished with bony palates, and squat firmly-based teeth, well adapted for crushing the stone-cased zoophytes and shells of the period, fragments of which occur in their fœcal remains; some with teeth that, like those of the fossil sharks of the later formations, resemble lines of miniature pyramids, larger and smaller alternating; some with teeth sharp, thin, and so deeply serrated that every individual tooth resembles a row of poniards set upright against the walls of an armoury; and these last, says Agassiz, furnished with weapons so murderous, must have been the pirates of the period. Some had their fins guarded with long spines, hooked like the beak of an eagle; some with spines of straighter and more slender form, and ribbed and furrowed longitudinally like columns; some were shielded by an armour of bony points; and some thickly covered with glistening scales. If many ages must have passed ere fishes appeared, there was assuredly no time required to elevate their lower into their higher families. Judging, too, from this ancient deposit, they seem to

have been introduced, not by individuals and pairs, but by whole myriads.

> "Forthwith the sounds and seas, each creek and bay,
> With fry innumerable swarmed; and shoals
> Of fish, that with their fins and shining scales
> Glide under the green wave in plumps and sculls,
> Banked the mid sea."

The fish-bed of the Upper Ludlow Rock abounds more in osseous remains than an ancient burying-ground. The stratum, over wide areas, seems an almost continuous layer of matted bones, jaws, teeth, spines, scales, palatial plates, and shagreen-like prickles, all massed together, and converted into a substance of so deep and shining a jet colour, that the bed, when "first discovered, conveyed the impression," says Mr. Murchison, "that it enclosed a triturated heap of black beetles." And such are the remains of what seem to have been the first existing vertebrata. Thus, ere our history begins, the existences of two great systems, the Cambrian and the Silurian, had passed into extinction, with the exception of what seem a few connecting links, exclusively molluscs, that are found in England to pass from the higher beds of the Ludlow rocks into the lower or Tilestone beds of the Old Red Sandstone.* The exuviæ of at least four platforms of being lay entombed, furlong

* "Upwards of eight hundred extinct species of animals have been described as belonging to the earliest, or Protozoic and Silurian period, and of these only about one hundred are found also in the overlying Devonian series; while but fifteen are common to the whole Palæozoic period, and not one extends beyond it." (*M. de Verneuil and Count D'Archiac*, quoted by Mr. D. T. Ansted. 1844.)

below furlong, amid the grey mouldering mudstones, the harder arenaceous beds, the consolidated clays, and the concretionary limestones, that underlay the ancient ocean of the Lower Old Red. The earth had already become a vast sepulchre, to a depth beneath the bed of the sea equal to at least twice the height of Ben Nevis over its surface.

The first scene in the *Tempest* opens amid the confusion and turmoil of the hurricane—amid thunders and lightnings, the roar of the wind, the shouts of the seamen, the rattling of cordage, and the wild dash of the billows. The history of the period represented by the Old Red Sandstone seems, in what now forms the northern half of Scotland, to have opened in a similar manner. The finely-laminated lower Tilestones of England were deposited evidently in a calm sea. During the cotemporary period in our own country, the vast space which now includes Orkney and Lochness, Dingwall and Gamrie, and many a thousand square mile besides, was the scene of a shallow ocean, perplexed by powerful currents, and agitated by waves. A vast stratum of water-rolled pebbles, varying in depth from a hundred feet to a hundred yards, remains in a thousand different localities, to testify of the disturbing agencies of this time of commotion. The hardest masses which the stratum encloses—porphyries of vitreous fracture that cut glass as readily as flint, and masses of quartz that strike fire quite as profusely from steel—are yet polished and ground down into bullet-like forms, not an angular fragment appearing in some parts of the mass for yards together. The debris of our harder rocks

rolled for centuries in the beds of our more impetuous rivers, or tossed for ages along our more exposed and precipitous sea-shores, could not present less equivocally the marks of violent and prolonged attrition than the pebbles of this bed. And yet it is surely difficult to conceive how the bottom of any sea should have been so violently and so equally agitated for so greatly extended a space as that which intervenes between Mealforvonie in Inverness-shire and Pomona in Orkney in one direction, and between Applecross and Trouphead in another—and for a period so prolonged, that the entire area should have come to be covered with a stratum of rolled pebbles of almost every variety of ancient rock, fifteen storeys' height in thickness. The very variety of its contents shows that the period must have been prolonged. A sudden flood sweeps away with it the accumulated debris of a range of mountains; but to blend together, in equal mixture, the debris of many such ranges, as well as to grind down their roughnesses and angularities, and fill up the interstices with the sand and gravel produced in the process, must be a work of time. I have examined with much interest, in various localities, the fragments of ancient rock enclosed in this formation. Many of them are no longer to be found *in situ*, and the group is essentially different from that presented by the more modern gravels. On the shores of the Frith of Cromarty, for instance, by far the most abundant pebbles are of a blue schistose gneiss: fragments of grey granite and white quartz are also common; and the sea-shore at half-ebb presents at a short distance the appearance of a long

belt of bluish grey, from the colour of the prevailing stones which compose it. The prevailing colour of the conglomerate of the district, on the contrary, is a deep red. It contains pebbles of small-grained red granite, red quartz rock, red feldspar, red porphyry, an impure red jasper, red hornstone, and a red granitic gneiss, identical with the well-marked gneiss of the neighbouring Sutors. This last is the only rock now found in the district, of which fragments occur in the conglomerate. It must have been exposed at the time to the action of the waves, though afterwards buried deep under succeeding formations, until again thrust to the surface by some great internal convulsion, of a date comparatively recent.*

The period of this shallow and stormy ocean passed. The bottom, composed of the identical conglomerate which now forms the summit of some of our loftiest mountains, sank throughout its wide area to a depth so profound as to be little affected by tides or tem-

* The vast beds of unconsolidated gravel with which one of the later geological revolutions has half-filled some of our northern valleys, and covered the slopes of the adjacent hills, present, in a few localities, appearances somewhat analogous to those exhibited by this ancient formation. There are uncemented accumulations of water-rolled pebbles, in the neighbourhood of Inverness, from ninety to a hundred feet in thickness. But this stratum, unlike the more ancient one, wanted continuity. It must have been accumulated, too, under the operation of more partial, though immensely more powerful agencies. There is a mediocrity of size in the enclosed fragments of the old conglomerate, which gives evidence of a mediocrity of power in the transporting agent. In the upper gravels, on the contrary, one of the agents could convey from vast distances blocks of stone eighty and a hundred tons in weight. A new cause of tremendous energy had come into operation in the geological world.

pests. During this second period there took place a vast deposit of coarse sandstone strata, with here and there a few thin beds of rolled pebbles. The general subsidence of the bottom still continued, and after a deposit of fully ninety feet had overlain the conglomerate, the depth became still more profound than at first. A fine semi-calcareous, semi-aluminous deposition took place in waters perfectly undisturbed. And here we first find proof that this ancient ocean literally swarmed with life—that its bottom was covered with miniature forests of algæ, and its waters darkened by immense shoals of fish.

In middle autumn, at the close of the herring season, when the fish have just spawned, and the congregated masses are breaking up on shallow and skerry, and dispersing by myriads over the deeper seas, they rise at times to the surface by a movement so simultaneous, that for miles and miles around the skiff of the fisherman nothing may be seen but the bright glitter of scales, as if the entire face of the deep were a blue robe spangled with silver. I have watched them at sunrise at such seasons on the middle of the Moray Frith, when, far as the eye could reach, the surface has been ruffled by the splash of fins, as if a light breeze swept over it, and the red light has flashed in gleams of an instant on the millions and tens of millions that were leaping around me, a handbreadth into the air, thick as hailstones in a thunder-shower. The amazing amount of life which the scene included has imparted to it an indescribable interest. On most occasions the inhabitants of ocean are seen but by scores and hun-

dreds; for in looking down into their green twilight haunts, we find the view bounded by a few yards, or at most a few fathoms; and we can but calculate on the unseen myriads of the surrounding expanse, by the seen few that occupy the narrow space visible. Here, however, it was not the few, but the myriads, that were seen—the innumerable and inconceivable whole—all palpable to the sight as a flock on a hill-side; or at least, if all was not palpable, it was only because sense has its limits in the lighter as well as in the denser medium—that the multitudinous distracts it, and the distant eludes it, and the far horizon bounds it. If the scene spoke not of infinity in the sense in which Deity comprehends it, it spoke of it in at least the only sense in which man can comprehend it.

Now, we are much in the habit of thinking of such amazing multiplicity of being—when we think of it at all—with reference to but the later times of the world's history. We think of the remote past as a time of comparative solitude. We forget that the now uninhabited desert was once a populous city. Is the reader prepared to realize, in connection with the Lower Old Red Sandstone—the second period of vertebrated existence—scenes as amazingly fertile in life as the scene just described—oceans as thoroughly occupied with being as our friths and estuaries when the herrings congregate most abundantly on our coasts? There are evidences too sure to be disputed that such must have been the case. I have seen the ichthyolite beds, where washed bare in the line of the strata, as thickly covered with oblong

spindle-shaped nodules as I have ever seen a fishing bank covered with herrings; and have ascertained that every individual nodule had its nucleus of animal matter—that it was a stone coffin in miniature, holding enclosed its organic mass of bitumen or bone—its winged, or enamelled, or thorn-covered ichthyolite.

At this period of our history some terrible catastrophe involved in sudden destruction the fish of an area at least a hundred miles from boundary to boundary, perhaps much more. The same platform in Orkney as at Cromarty is strewed thick with remains, which exhibit unequivocally the marks of violent death. The figures are contorted, contracted, curved; the tail in many instances is bent round to the head; the spines stick out; the fins are spread to the full, as in fish that die in convulsions. The *Pterichthys* shows its arms extended at their stiffest angle, as if prepared for an enemy. The attitudes of all the ichthyolites on this platform are attitudes of fear, anger, and pain. The remains, too, appear to have suffered nothing from the after attacks of predaceous fishes: none such seem to have survived. The record is one of destruction at once widely spread and total, so far as it extended. There are proofs, that whatever may have been the cause of the catastrophe, it must have taken place in a sea unusually still. The scales, when scattered by some slight undulation, are scattered to the distance of only a few inches, and still exhibit their enamel entire, and their peculiar fineness of edge. The spines, even when separated, retain their original

needle-like sharpness of point. Rays well-nigh as slender as horse-hairs are enclosed unbroken in the mass. Whole ichthyolites occur, in which not only all the parts survive, but even the expression which the stiff and threatening attitude conveyed when the last struggle was over. Destruction must have come in the calm, and it must have been of a kind by which the calm was nothing disturbed. In what could it have originated? By what quiet but potent agency of destruction were the innumerable existences of an area perhaps ten thousand square miles in extent annihilated at once, and yet the medium in which they had lived left undisturbed by its operations? Conjecture lacks footing in grappling with the enigma, and expatiates in uncertainty over all the known phenomena of death. Diseases of mysterious origin break out at times in the animal kingdom, and well-nigh exterminate the tribes on which they fall. The present generation has seen a hundred millions of the human family swept away by a disease unknown to our fathers. Virgil describes the fatal murrain that once depopulated the Alps, not more as a poet than as a historian. The shell-fish of the rivers of North America died in such vast abundance during a year of the present century, that the animals, washed out of their shells, lay rotting in masses beside the banks, infecting the very air. About the close of the last century the haddock well-nigh disappeared for several seasons together from the eastern coasts of Scotland; and it is related by Creech, that a Scotch shipmaster of the period sailed for several leagues on the coast of Norway, about the time the scarcity began, through a

floating shoal of dead haddocks.* But the ravages of no such disease, however extensive, could well account for some of the phenomena of this platform of death.

* I have heard elderly fishermen of the Moray Frith state, in connection with what they used to term "the haddock dearth" of this period, that for several weeks ere the fish entirely disappeared, they acquired an extremely disagreeable taste, as if they had been boiled in tobacco-juice, and became unfit for the table. For the three following years they were extremely rare on the coast, and several years more elapsed ere they were caught in the usual abundance. The fact related by Creech, a very curious one, I subjoin in his own words; it occurs in his third *Letter to Sir John Sinclair:* "On Friday, the 4th December 1789, the ship *Brothers*, Captain Stewart, arrived at Leith from Archangel, who reported that on the coast of Lapland and Norway, he sailed many leagues through immense quantities of dead haddocks floating on the sea. He spoke several English ships, who reported the same fact. It is certain that haddocks, which was the fish in the greatest abundance in the Edinburgh market, have scarcely been seen there these three years. In February 1790 three haddocks were brought to market, which, from their scarcity, sold for 7s. 6d."

The dead haddocks seen by the Leith shipmaster were floating by thousands; and most of their congeners among what fishermen term "the white fish," such as cod, ling, and whiting, also float when dead; whereas the bodies of fish whose bowels and air-bladders are comparatively small and tender, lie at the bottom. The herring-fisherman, if the fish die in his nets, finds it no easy matter to buoy them up; and if the shoal entangled be a large one, he fails at times, from the great weight, in recovering them at all, losing both nets and herrings. Now, if a corresponding difference obtained among fish of the extinct period—if some rose to the surface when they died, while others remained at the bottom—we must, of course, expect to find their remains in very different degrees of preservation—to find only scattered fragments of the floaters, while of the others many may occur comparatively entire. Even should they have died on the same beds, too, we may discover their remains separated by hundreds of miles. The haddocks that disappeared from the coast of Britain were found

It is rarely that disease falls equally on many different tribes at once, and never does it fall with instantaneous suddenness; whereas in the ruin of this platform from ten to twelve distinct genera seem to have been equally involved; and so suddenly did it perform its work, that its victims were fixed in their first attitude of terror and surprise. I have observed, too, that groups of adjoining nodules are charged frequently with fragments of the same variety of ichthyolite; and the circumstance seems fraught with evidence regarding both the original habits of the creatures, and the instantaneous suddenness of the destruction by which they were overtaken. They seem, like many of our existing fish, to have been gregarious, and to have perished together ere their crowds had time to break up and disperse.

Fish have been found floating dead in shoals beside submarine volcanoes—killed either by the heated water or by mephitic gases. There are, however, no marks of volcanic activity in connection with the ichthyolite beds—no marks at least which belong to nearly the same age with the fossils. The disturbing

floating in shoals on the coasts of Norway. The remains of an immense body of herrings, that weighed down, a few seasons since, the nets of a crew of fishermen, in a muddy hollow of the Moray Frith, and defied the utmost exertions of three crews united to weigh them from the bottom, are, I doubt not, in the muddy hollow still. On a principle thus obvious it may be deemed not improbable that the ichthyolites of the Lower Old Red Sandstone might have had numerous cotemporaries, of which, unless in some instances the same accident which killed also entombed them, we can know nothing in their character as such, and whose broken fragments may yet be found in some other locality, where they may be regarded as characteristic of a different formation.

granite of the neighbouring eminences was not upheaved until after the times of the Oolite. But the volcano, if such was the destroying agent, might have been distant; nay, from some of the points in an area of such immense extent, it *must* have been distant. The beds abound, as has been said, in lime; and the thought has often struck me that calcined lime, cast out as ashes from some distant crater, and carried by the winds, might have been the cause of the widely-spread destruction to which their organisms testify. I have seen the fish of a small trouting stream, over which a bridge was in the course of building, destroyed in a single hour, for a full mile below the erection, by the few troughfuls of lime that fell into the water when the centring was removed.

CHAPTER XIII.

Successors of the exterminated Tribes—The Gap slowly filled—Proof that the Vegetation of a Formation may long survive its Animal Tribes—Probable Cause—Immensely extended Period during which Fishes were the Master-existences of our Planet—Extreme Folly of an Infidel Objection illustrated by the Fact—Singular Analogy between the History of Fishes as Individuals and as a Class—Chemistry of the Lower Formation—Principles on which the Fish-enclosing Nodules were probably formed—Chemical Effect of Animal Matter in discharging the Colour from Red Sandstone—Origin of the prevailing Tint to which the System owes its Name—Successive Modes in which a Metal may exist—The Restorations of the Geologist void of Colour—Very different Appearance of the Ichthyolites of Cromarty and Moray.

The period of death passed, and over the innumerable dead there settled a soft muddy sediment, that hid them from the light, bestowing upon them such burial as a November snow-storm bestows on the sere and blighted vegetation of the previous summer and autumn. For an unknown space of time, represented in the formation by a deposit about fifty feet in thickness, the waters of the depopulated area seem to have remained devoid of animal life. A few scales and plates then begin to appear. The fish that had existed outside the chasm seem to have gradually

gained upon it, as their numbers increased, just as the European settlers of America have been gaining on the backwoods, and making themselves homes amid the burial mounds of a race extinct for centuries. For a lengthened period, however, these finny settlers must have been comparatively few—mere squatters in the waste. In the beds of stratified clay in which their remains first occur, over what we may term the densely crowded platform of violent death, the explorer may labour for hours together without finding a single scale.

It is worthy of remark, however, that this upper bed abounds quite as much in the peculiar vegetable impressions of the formation as the lower platform itself. An abundance equally great occurs in some localities only a few inches over the line of the exterminating catastrophe. Thickets of exactly the same algæ, amid which the fish of the formation had sheltered when living, grew luxuriantly over their graves when dead. The agencies of destruction which annihilated the animal life of so extended an area, spared its vegetation; just as the identical forests that had waved over the semi-civilized aborigines of North America continued to wave over the more savage red men, their successors, long after the original race had been exterminated. The inference deducible from the fact, though sufficiently simple, seems in a geological point of view a not unimportant one. *The flora of a system may long survive its fauna; so that that may be but one formation, regarded with reference to plants, which may be two or more formations, regarded with reference to animals.*

No instance of any such phenomenon occurs in the later geological periods. The changes in animal and vegetable life appear to have run parallel to each other from the times of the tertiary formations down to those of the coal; but in the earlier deposits the case must have been different. The animal organisms of the newer Silurian strata form essentially different groups from those of the Lower Old Red Sandstone, and both differ from those of the Cornstone divisions; and yet the greater portion of their vegetable remains seem the same. The stem-like impressions of the fucoid bed of the Upper Ludlow Rocks cannot be distinguished from those of the ichthyolite beds of Cromarty and Ross, nor these again from the impressions of the Arbroath pavement, or the Den of Balruddery. Nor is there much difficulty in conceiving how the vegetation of a formation should come to survive its animals. What is fraught with health to the existences of the vegetable kingdom is in many instances a deadly poison to those of the animal. The grasses and water-lilies of the neighbourhood of Naples flourish luxuriantly amid the carbonic acid gas which rests so densely over the pools and runnels out of which they spring, that the bird stoops to drink, and falls dead into the water. The lime that destroys the reptiles, fish, and insects of a thickly-inhabited lake or stream, injures not a single flag or bulrush among the millions that line its edges. The two kingdoms exist under laws of life and death so essentially dissimilar, that it has become one of the common-places of poetry to indicate the blight and decline of the tribes of the one by the unwonted luxu-

riancy of the productions of the other. Otway tells us, in describing the horrors of the plague which almost depopulated London, that the "destroying angel stretched his arm" over the city,

> "Till in th' untrodden streets unwholesome grass
> Grew of great stalk, and colour gross,
> A melancholic poisonous green."

The work of deposition went on; a bed of pale yellow saliferous sandstone settled, tier over tier, on a bed of stratified clay, and was itself overlaid by another bed of stratified clay in turn. And this upper bed had also its organisms. The remains of its sea-weed still spread out thick and dark amid the foldings of the strata, and occasionally its clusters of detached scales. But the circumstances were less favourable to the preservation of entire ichthyolites than those under which the organisms of the lower platform were wrapped up in their stony coverings. The matrix, which is more micaceous than the other, seems to have been less conservative, and the waters were probably less still. The process went on. Age succeeded age, and one stratum covered up another. Generations lived, died, and were entombed in the ever-growing depositions. Succeeding generations pursued their instincts by myriads, happy in existence, over the surface which covered the broken and perishing remains of their predecessors, and then died and were entombed in turn, leaving a higher platform and a similar destiny to the generations that succeeded. Whole races became extinct, through what process of destruction who can tell? Other races sprang into

existence through that adorable power which One only can conceive, and One only can exert. An inexhaustible variety of design expatiated freely within the limits of the ancient type. The main conditions remained the same—the minor details were dissimilar. Vast periods passed; a class low in the scale still continued to furnish the master-existences of creation; and so immensely extended was the term of its sovereignty, that a being of limited faculties, if such could have existed uncreated, and witnessed the whole, would have inferred that the power of the Creator had reached its extreme boundary when fishes had been called into existence, and that our planet was destined to be the dwelling-place of no nobler inhabitants. If there be men dignified by the name of philosophers, who can hold that the present state of being, with all its moral evil and all its physical suffering, is to be succeeded by no better and happier state, just because "all things have continued as they were" for some five or six thousand years, how much sounder and more conclusive would the inference have been which could have been based, as in the supposed case, on a period perhaps a hundred times more extended?

There exist wonderful analogies in nature between the geological history of the vertebrated animals as an order, and the individual history of every mammifer —between the history, too, of fish as a class, and that of every single fish. "'It has been found by Tiedemann," says Mr. Lyell, "that the brain of the fœtus in the higher class of vertebrated animals assumes in succession the various forms which belong to fishes,

reptiles, and birds, before it acquires those additions and modifications which are peculiar to the mammiferous tribes." "In examining the brain of the mammalia," says M. Serres, "at an early stage of life, you perceive the cerebral hemispheres consolidated, as in fish, in two vesicles isolated one from the other; at a later period you see them affect the configuration of the cerebral hemispheres of reptiles; still later, again, they present you with the forms of those of birds; and finally, at the era of birth, the permanent forms which the adult mammalia present." And such seems to have been the history of the vertebrata as an order, as certainly as that of the individual mammifer. The fish preceded the reptile in the order of creation, just as the crustacean had preceded the fish, and the annelid the crustacean. Again, though the fact be somewhat more obscure, the reptile seems to have preceded the bird. We find, however, unequivocal traces of the feathered tribes in well marked foot-prints impressed on a sandstone in North America, at most not more modern than the Lias, but which is generally supposed to be of the same age with the New Red Sandstone of Germany and our own country. In the Oolite—at least one, perhaps two formations later—the bones of the two species of mammiferous quadrupeds have been found, apparently of the marsupial family; and these, says Mr. Lyell, afford the only example yet known of terrestrial mammalia in rocks of a date anterior to the older tertiary formations. The reptile seems to have preceded the bird, and the bird the mammiferous animal. Thus the fœtal history of the nervous system in the individual

mammifer seems typical, in every stage of its progress, of the history of the grand division at the head of which the mammifer stands. Agassiz, at the late meeting of the British Association in Glasgow, mentioned an analogous fact. After describing the one-sided tail of the more ancient fish, especially the fish of the Old Red Sandstone—the subjects of his illustration at the time—he stated, as the result of a recent discovery, that the young of the salmon in their fœtal state exhibit the same unequally-sided condition of tail which characterizes those existences of the earlier ages of the world. The individual fish, just as it begins to exist, presents the identical appearances which were exhibited by the order when the order began to exist.* Is there nothing wonderful in analogies such as these—analogies that point through the embryos of the present time to the womb of Nature, big with its multitudinous forms of being? Are they charged with no such nice evidence as a Butler would delight to contemplate, regarding that unique *style* of Deity, if I may so express myself, which runs through all his works, whether we consider him as God of Nature, or Author of Revelation? In this style of type and symbol did He reveal himself of old to his chosen people: in this style of allegory and parable did He again address himself to them, when he sojourned among them on earth.

The chemistry of the formation seems scarce inferior in interest to its zoology; but the chemist had still much to do for Geology, and the processes are but imperfectly known. There is no field in which

more laurels await the philosophical chemist than the geological one. I have said that all the calcareous nodules of the ichthyolite beds seem to have had originally their nucleus of organic matter. In nine cases out of ten the organism can be distinctly traced; and in the tenth there is almost always something to indicate where it lay—an elliptical patch of black, or an oblong spot, from which the prevailing colour of the stone has been discharged, and a lighter hue substituted. Is the reader acquainted with Mr. Pepys' accidental experiment, as related by Mr. Lyell, and recorded in the first volume of the *Geological Transactions?* It affords an interesting proof that animal matter, in a state of putrefaction, proves a powerful agent in the decomposition of mineral substances held in solution, and of their consequent precipitation. An earthen pitcher, containing several quarts of sulphate of iron, had been suffered to remain undisturbed and unexamined, in a corner of Mr. Pepys' laboratory, for about a twelvemonth. Some luckless mice had meanwhile fallen into it and been drowned; and when it at length came to be examined, an oily scum and a yellow sulphureous powder, mixed with hairs, were seen floating on the top, and the bones of the mice discovered lying at the bottom; and it was found, that over the decaying bodies the mineral components of the fluid had been separated and precipitated in a dark-coloured sediment, consisting of grains of pyrites and of sulphur, of copperas in its green and crystalline form, and of black oxide of iron. The animal and mineral matters had mutually acted upon one another; and the metallic sulphate, deprived of its oxygen in

the process, had thus cast down its ingredients. It would seem that over the putrefying bodies of the fish of the Lower Old Red Sandstone the water had deposited, in like manner, the lime with which it was charged; and hence the calcareous nodules in which we find their remains enclosed. The form of the nodule almost invariably agrees with that of the ichthyolite within: it is a coffin in the ancient Egyptian style. Was the ichthyolite twisted half round in the contorted attitude of violent death? the nodule has also its twist. Did it retain its natural posture? the nodule presents the corresponding spindle form. Was it broken up, and the outline destroyed? the nodule is flattened and shapeless. In almost every instance the form of the organism seems to have regulated that of the stone. We may trace, in many of these concretionary masses, the operations of three distinct principles, all of which must have been in activity at one and the same time. They are wrapped concentrically each round its organism: they split readily in the line of the enclosing stratum, and are marked by its alternating rectilinear bars of lighter and darker colour; and they are radiated from the centre to the circumference. Their concentric condition shows the chemical influences of the decaying animal matter; their fissile character and parallel layers of colour indicate the general deposition which was taking place at the time; and their radiated structure testifies to that law of crystalline attraction, through which, by a wonderful masonry, the invisible but well-cut atoms build up their cubes, their rhombs, their hexagons, and their pyramids, and are at once

the architects and the materials of the structure which they rear.

Another and very different chemical effect of organic matter may be remarked in the darker-coloured arenaceous deposits of the formation, and occasionally in the stratified clays and nodules of the ichthyolite bed. In a print-work the whole web is frequently thrown into the vat and dyed of one colour; but there afterwards comes a discharging process: some chemical mixture is dropped on the fabric; the dye disappears wherever the mixture touches; and in leaves, and sprigs, and patches, according to the printer's pattern, the cloth assumes its original white. Now the coloured deposits of the Old Red Sandstone have, in like manner, been subjected to a discharging process. The dye has disappeared in oblong or circular patches of various sizes, from the eighth of an inch to a foot in diameter; the original white has taken its place; and so thickly are these speckles grouped in some of the darker-tinted beds, that the surfaces, where washed by the sea, present the appearance of sheets of calico. The discharging agent was organic matter; the uncoloured patches are no mere surface films, for, when cut at right angles, their depth is found to correspond with their breadth, the circle is a sphere, the ellipsis forms the section of an egg-shaped body, and in the centre of each we generally find traces of the organism in whose decay it originated. I have repeatedly found single scales, in the ichthyolite beds, surrounded by uncoloured spheres about the size of musket-bullets. It is well for the young geologist carefully to mark such appear-

ances—to trace them through the various instances in which the organism may be recognised and identified, to those in which its last vestiges have disappeared. They are the hatchments of the geological world, and indicate that life once existed where all other record of it has perished.*

* Some of the clay slates of the primary formations abound in these circular uncoloured patches, bearing in their centres, like the patches of the Old Red Sandstone, half-obliterated nuclei of black. Were they too once fossiliferous, and do these blank erasures remain to testify to the fact? I find the organic origin of the patches in the Old Red Sandstone remarked by Professor Fleming as early as the year 1830, and the remark reiterated by Dr. Anderson of Newburgh in nearly the same words, but with no acknowledgment, ten years later. The following is the minute and singularly faithful description of the Professor:—

"On the surface of the strata in the lower beds, circular spots, nearly a foot in diameter, may be readily perceived by their pale-yellow colours, contrasted with the dark-red of the surrounding rock. These spots, however, are not, as may at first be supposed, mere superficial films, but derive their circular form from a coloured sphere to which they belong. This sphere is not to be distinguished from the rest of the bed by any difference in mechanical structure, but merely by the absence of much of that oxide of iron with which the other portion of the mass is charged. The circumference of this coloured sphere is usually well defined; and at its centre may always be observed matter of a darker colour, in some cases disposed in concentric layers, in others of calcareous and crystalline matter, the remains probably of some vegetable or animal organism, the decomposition of which exercised a limited influence on the colouring matter of the surrounding rock. In some cases I have observed these spheres slightly compressed at opposite sides, in a direction parallel with the plane of stratification—the result, without doubt, of the subsidence or contraction of the mass, after the central matter or nucleus had ceased to exercise its influence." (*Cheek's Edinburgh Journal*, Feb. 1831, p. 82.)

It is the part of the chemist to tell us by what peculiar action of the organic matter the dye was discharged in these spots and patches. But how was the dye itself procured? From what source was the immense amount of iron derived, which gives to nearly five-sixths of the Old Red Sandstone the characteristic colour to which it owes its name? An examination of its lowest member, the great conglomerate, suggests a solution of the query. I have adverted to the large proportion of red-coloured pebbles which this member contains, and, among the rest, to a red granitic gneiss, which must have been exposed over wide areas at the time of its deposition, and which, after the lapse of a period which extended from at least the times of the Lower Old Red to those of the Upper Oolite, was again thrust upwards to the surface, to form the rectilinear chain of precipitous eminences to which the hills of Cromarty and of Nigg belong. This rock is now almost the sole representative, in the north of Scotland, of the ancient rocks whence the materials of the Old Red Sandstone were derived. It abounds in hæmatic iron-ore, diffused as a component of the stone throughout the entire mass, and which also occurs in it in ponderous insulated blocks of great richness, and in thin thread-like veins. When ground down, it forms a deep red pigment, undistinguishable in tint from the prevailing colour of the Sandstone, and which leaves a stain so difficult to be effaced, that shepherds employ it in some parts of the Highlands for marking their sheep. Every rawer fragment of the rock bears its hæmatic tinge; and were the whole ground by some mechanical

process into sand, and again consolidated, the produce of the experiment would be undoubtedly a deep red sandstone. In an upper member of the lower formation—that immediately over the ichthyolite beds—different materials seem to have been employed. A white quartzy sand and a pale-coloured clay form the chief ingredients; and though the ochry-tinted colouring matter be also iron, it is iron existing in a different condition, and in a more diluted form. The oxide deposited by the chalybeate springs which pass through the lower members of the formation, would give to white sand a tinge exactly resembling the tint borne by this upper member.

The passage of metals from lower to higher formations, and from one combination to another, constitutes surely a highly interesting subject of inquiry. The transmission of iron in a chemical form, through chalybeate springs, from deposits in which it had been diffused in a form merely mechanical, is of itself curious; but how much more so its passage and subsequent accumulation, as in bog-iron and the iron of the Coal Measures, through the agency of vegetation! How strange, if the steel axe of the woodman should have once formed part of an ancient forest!—if, after first existing as a solid mass in a primary rock, it should next have come to be diffused as a red pigment in a transition conglomerate—then as a brown oxide in a chalybeate spring—then as a yellowish ochre in a secondary sandstone—then as a component part in the stems and twigs of a thick forest of arboraceous plants—then again as an iron carbonate slowly accumulating at the bottom of a

morass of the Coal Measures—then as a layer of indurated bands and nodules of brown ore underlying a seam of coal—and then, finally, that it should have been dug out, and smelted, and fashioned, and employed for the purpose of handicraft, and yet occupy, even at this stage, merely a middle place between the transmigrations which have passed, and the changes which are yet to come. Crystals of galena sometimes occur in the nodular limestones of the Old Red Sandstone; but I am afraid the chemist would find it difficult to fix their probable genealogy.

In at least one respect every geological history must of necessity be unsatisfactory; and ere I pass to the history of the two upper formations of the system, the reader must permit me to remind him of it. There have been individuals, it has been said, who, though they could see clearly the forms of objects, wanted, through some strange organic defect, the faculty of perceiving their distinguishing colours, however well marked these might be. The petals of the rose have appeared to them of the same sombre hue with its stalk: and they have regarded the ripe scarlet cherry as undistinguishable in tint from the green leaves under which it hung. The face of nature to such men must have for ever rested under a cloud; and a cloud of similar character hangs over the pictorial restorations of the geologist. The history of this and the last chapter is a mere profile drawn in black, an outline without colour—in short, such a chronicle of past ages as might be reconstructed, in the lack of other and ampler materials, from tombstones and charnel-houses. I have had to draw the portrait from

the skeleton. My specimens show the general form of the creatures I attempt to describe, and not a few of their more marked peculiarities; but many of the nicer elegancies are wanting; and the "complexion to which they have come" leaves no trace by which to discover the complexion they originally bore. And yet colour is a mighty matter to the ichthyologist. The "fins and shining scales," "the waved coats, dropt with gold," the rainbow dyes of beauty of the watery tribes, are connected often with more than mere external character. It is a curious and interesting fact, that the hues of splendour in which they are bedecked are, in some instances, as intimately associated with their instincts—with their feelings, if I may so speak—as the blush which suffuses the human countenance is associated with the sense of shame, or its tint of ashy paleness or of sallow with emotions of rage, or feelings of a panic terror. Pain and triumph have each their index of colour among the mute inhabitants of our seas and rivers. Poets themselves have bewailed the utter inadequacy of words to describe the varying tints and shades of beauty with which the agonies of death dye the scales of the dolphin, and how every various pang calls up a various suffusion of splendour.* Even the common

* The description of Falconer must be familiar to every reader, but I cannot resist quoting it. It shows how minutely the sailor poet must have observed. Byron tells us how

"Parting day
Dies like the dolphin, whom each pang imbues
With a new colour, as it gasps away,
The last still loveliest, till—'tis gone, and all is grey."

Falconer, in anticipating, reversed the simile. The huge animal,

stickleback of our ponds and ditches can put on its colours to picture its emotions. There is, it seems, a mighty amount of ambition, and a vast deal of fighting sheerly for conquest' sake, among the myriads of this pigmy little fish which inhabit our smaller streams; and no sooner does an individual succeed in expelling his weaker companions from some eighteen inches or two feet of territory, than straightway the exultation of conquest converts the faded and freckled olive of his back and sides into a glow of crimson and bright green. Nature furnishes him with a regal robe for the occasion. Immediately on his deposition, however—and events of this kind are even more common under than out of the water—his gay colours disappear, and he sinks into his original and native ugliness.*

stuck by the "unerring barb" of Rodmond, has been drawn on board, and

"On deck he struggles with convulsive pain.
But while his heart the fatal javelin thrills,
And flitting life escapes in sanguine rills,
What radiant changes strike the astonished sight!
What glowing hues of mingled shade and light!
Not equal beauties gild the lucid west
With parting beams o'er all profusely drest;
Not lovelier colours paint the vernal dawn,
When Orient dews impearl the enamell'd lawn;
Than from his sides in bright suffusion flow,
That now with gold empyreal seem to glow;
Now in pellucid sapphires meet the view,
And emulate the soft celestial hue;
Now beam a flaming crimson on the eye,
And now assume the purple's deeper dye.
But here description clouds each shining ray—
What terms of art can Nature's powers display?"

* "In the *Magazine of Natural History*," says Captain Brown,

But of colour, as I have said, though thus important, the ichthyologist can learn almost nothing from Geology. The perfect restorations of even a Cuvier

in one of his notes to White's *Selborne*, "we have a curious account of the pugnacious propensities of these little animals. 'Having at various times,' says a correspondent, 'kept these little fish during the spring and part of the summer months, and paid close attention to their habits, I am enabled from my own experience to vouch for the facts I am about to relate. I have frequently kept them in a deal tub, about three feet two inches wide, and about two feet deep. When they are put in for some time, probably a day or two, they swim about in a shoal, apparently exploring their new habitation. Suddenly one will take possession of the tub, or, as it will sometimes happen, the bottom, and will instantly commence an attack upon his companions; and if any of them venture to oppose his sway, a regular and most furious battle ensues. They swim round and round each other with the greatest rapidity, biting (their mouths being well furnished with teeth), and endeavouring to pierce each other with their lateral spines, which on this occasion are projected. I have witnessed a battle of this sort which lasted several minutes before either would give way; and when one does submit, imagination can hardly conceive the vindictive fury of the conqueror, who, in the most persevering and unrelenting way, chases his rival from one part of the tub to another, until fairly exhausted with fatigue. From this period an interesting change takes place in the conqueror, who, from being a speckled and greenish-looking fish, assumes the most beautiful colours; the belly and lower jaws becoming a deep crimson, and the back sometimes a cream-colour, but generally a fine green, and the whole appearance full of animation and spirit. I have occasionally known three or four parts of the tub taken possession of by these little tyrants, who guard their territories with the strictest vigilance, and the slightest invasion brings on invariably a battle. A strange alteration immediately takes place in the defeated party: his gallant bearing forsakes him, his gay colours fade away, he becomes again speckled and ugly, and he hides his disgrace among his peaceable companions.'"

are blank outlines. We just know by a wonderful accident that the Siberian elephant was red. A very few of the original tints still remain among the fossils of our north-country Lias. The ammonite, when struck fresh from the surrounding lime, reflects the prismatic colours, as of old; a huge modiola still retains its tinge of tawny and yellow; and the fossilized wood of the formation preserves a shade of the native tint, though darkened into brown. But there is considerably less of colour in the fossils of the Old Red Sandstone. I have caught, and barely caught, in some of the newly-disinterred specimens, the faint and evanescent reflection of a tinge of pearl; and were I acquainted with my own collection only, imagination, borrowing from the prevailing colour, would be apt to people the ancient oceans in which its forms existed, with swarthy races exclusively. But a view of the Altyre fossils would correct the impression. They are enclosed, like those of Cromarty, in nodules of an argillaceous limestone. The colour, however, from the presence of iron and the absence of bitumen, is different. It presents a mixture of grey, of pink, and of brown; and on this ground the fossil is spread out in strongly-contrasted masses of white and dark red, of blue and of purple. Where the exuviæ lie thickest, the white appears tinged with delicate blue—the bone is but little changed. Where they are spread out more thinly, the iron has pervaded them, and the purple and deep red prevail. Thus the same ichthyolite presents, in some specimens, a body of white and plum-blue attached to fins of deep red, and with detached scales of red and of purple lying scattered

around it. I need hardly add, however, that all this variety of colouring is, like the unvaried black of the Cromarty specimens, the result merely of a curious chemistry.

CHAPTER XIV.

The Cornstone Formation and its Organisms—Dwarf Vegetation—*Cephalaspides*—Huge Lobster—Habitats of the existing Crustacea—No unapt Representation of the Deposit of Balruddery, furnished by a land-locked Bay in the neighbourhood of Cromarty—Vast Space occupied by the Geological Formations—Contrasted with the half-formed Deposits which represent the existing Creation—Inference—The Formation of the *Holoptychius*—Probable origin of its Siliceous Limestone—Marked increase in the Bulk of the Existences of the System—Conjectural Cause—The Coal Measures—The Limestone of Burdiehouse—Conclusion.

THE curtain rises, and the scene is new. The myriads of the lower formation have disappeared, and we are surrounded, on an upper platform, by the existences of a later creation. There is sea all around, as before; and we find beneath, a dark-coloured muddy bottom, thickly covered by a dwarf vegetation. The circumstances differ little from those in which the ichthyolite beds of the preceding period were deposited; but forms of life, essentially different, career through the green depths, or creep over the ooze. Shoals of *Cephalaspides*, with their broad arrow-like heads and their slender angular bodies, feathered with fins, sweep past like clouds of cross-bow bolts in an ancient battle.

We see the distant gleam of scales, but the forms are indistinct and dim: we can merely ascertain that the fins are elevated by spines of various shape and pattern; that of some the coats glitter with enamel; and that others—the sharks of this ancient period—bristle over with minute thorny points. A huge crustacean, of uncouth proportions, stalks over the weedy bottom, or burrows in the hollows of the banks.

Let us attempt bringing our knowledge of the present to bear upon the past. The larger crustacea of the British seas abound most on iron-bound coasts, where they find sheltering-places in the deeper fissures of sea-cliffs covered up by kelp and tangle, or under the lower edges of detached boulders, that rest unequally on uneven platforms of rock, amid forests of the rough-stemmed cuvy. We may traverse sandy or muddy shores for miles together, without finding a single crab, unless a belt of pebbles lines the upper zone of beach, where the forked and serrated fuci first appears, or a few weed-covered fragments of rock here and there occur in groups on the lower zones. In this formation, however, the bottom must have been formed of mingled sand and mud, and yet the crustacea were abundant. How account for the fact? There is, in most instances, an interesting conformity between the character of the ancient rocks, in which we find groups of peculiar fossils, and the habitats of those existences of the present creation which these fossils most resemble.[c] The fisherman casts his nets in a central hollow of the Moray Frith, about thirty fathoms in depth, and draws them up foul with masses of a fetid mud, charged with multitudes of that

curious purple-coloured zoophyte the sea-pen, invariably an inhabitant of such recesses. The graptolite of the most ancient fossiliferous rocks, an existence of unequivocally the same type, occurs in greatest abundance in a finely-levigated mudstone, for it too was a dweller in the mud. In like manner, we may find the ancient modiola of the Lias in habitats analogous to those of its modern representative the muscle, and the encrinite of the Mountain Limestone fast rooted to its rocky platform, just as we may see the Helianthoida and Ascidioida of our seas fixed to their boulders and rocky skerries. But is not analogy at fault in the present instance? Quite the reverse. Mark how thickly these carbonaceous impressions cover the muddy-coloured and fissile sandstones of the formation, giving evidence of an abundant vegetation. We may learn from these obscure markings, that the place in which they grew could have been no unfit habitat for the crustaceous tribes.

There is a little land-locked bay on the southern shore of the Frith of Cromarty, effectually screened from the easterly winds by the promontory on which the town is built, and but little affected by those of any other quarter, from the proximity of the neighbouring shores. The bottom, at low ebb, presents a level plain of sand, so thickly covered by the green grass-weed of our more sheltered sandy bays and estuaries, that it presents almost the appearance of a meadow. The roots penetrate the sand to the depth of nearly a foot, binding it firmly together; and as they have grown and decayed in it for centuries, it has acquired, from the disseminated particles of vegetable matter, a

deep leaden tint, more nearly approaching to black than even the dark grey mudstones of Balruddery. Nor is this the only effect: the intertwisted fibres impart to it such coherence, that, where scooped out into pools, the edges stand up perpendicular from the water, like banks of clay; and where these are hollowed into cave-like recesses—and there are few of them that are not so hollowed—the recesses remain unbroken and unfilled for years. The weeds have imparted to the sand a character different from its own, and have rendered it a suitable habitat for numerous tribes, which, in other circumstances, would have found no shelter in it. Now, among these we find in abundance the larger crustaceans of our coasts. The brown edible crab harbours in the hollows beside the pools: occasionally we may find in them an overgrown lobster, studded with parasitical shells and zoophytes—proof that the creature, having attained its full size, has ceased to cast its plated covering. Crustaceans of the smaller varieties abound. Hermit-crabs traverse the pools, or creep among the weed; the dark-green and the dingy hump-backed crabs occur nearly as frequently; the radiata cover the banks by thousands. We find occasionally the remains of dead fish left by the retreating tide; but the living are much more numerous than the dead; for the sand-eel has suffered the water to retire, and yet remained behind in its burrow; and the viviparous blenny and common gunnel still shelter beside their fuci-covered masses of rock. Imagine the bottom of this little bay covered up by thick beds of sand and gravel, and the whole consolidated into stone, and we have in it all the conditions of the de-

posit of Balruddery—a mud-coloured arenaceous deposit abounding in vegetable impressions, and enclosing numerous remains of crustaceans, fish, and radiata, as its characteristic organisms of the animal kingdom. There would be but one circumstance of difference: the little bay abounds in shells; whereas no shells have yet been found in the mudstones of Balruddery, or the grey sandstones of the same formation, which in Forfar, Fife, and Morayshires represent the Cornstone division of the system.

Ages and centuries passed, but who can sum up their number? In England the depth of this middle formation greatly exceeds that of any of the other two; in Scotland it is much less amply developed; but in either country it must represent periods of scarce conceivable extent. I have listened to the controversies of opposite schools of geologists, who from the earth's strata extract registers of the earth's age of an amount amazingly different. One class, regarding the geological field as if under the influence of those principles of perspective which give to the cottage in front more than the bulk and altitude of the mountain behind, would assign to the present scene of things its thousands of years, but to all the extinct periods united merely their few centuries; while with their opponents, the remoter periods stretch out far into the bygone eternity, and the present scene seems but a narrow strip running along the foreground. Both classes appeal to facts; and, leaving them to their disputes, I have gone out to examine and judge for myself. The better to compare the present with the past, I have regarded the existing scene merely as

a *formation*—not as superficies, but as depth; and have sought to ascertain the extent to which, in different localities, and under different circumstances, it has overlaid the surface.

The slopes of an ancient forest incline towards a river that flows sluggishly onwards through a deep alluvial plain, once an extensive lake. A recent land-slip has opened up one of the hanging thickets. Uprooted trees, mingled with bushes, lie at the foot of the slope, half-buried in broken masses of turf; and we see above, a section of the soil from the line of vegetation to the bare rock. There is an under belt of clay and an upper belt of gravel, neither of which contains anything organic; and overtopping the whole we may see a dark-coloured bar of mould, barely a foot in thickness, studded with stumps and interlaced with roots. Mark that narrow bar: it is the geological representative of six thousand years. A stony bar of similar appearance runs through the strata of the Wealden: it too has its dingy colour, its stumps, and its interlacing roots; but it forms only a very inconsiderable portion of one of the least considerable of all the formations; and yet who shall venture to say that it does not represent a period as extended as that represented by the dark bar in the ancient forest, seeing there is not a circumstance of difference between them?

We descend to the river side. The incessant action of the current has worn a deep channel through the leaden-coloured silt; the banks stand up perpendicularly over the water, and downwards, for twenty feet together—for such is the depth of the deposit—

we may trace layer after layer of reeds, and flags, and fragments of driftwood, and find here and there a few fresh-water shells of the existing species. In this locality six thousand years are represented by twenty feet. The depth of the various fossiliferous formations united is at least fifteen hundred times as great.

We pursue our walk, and pass through a morass. Three tiers of forest-trees appear in the section laid open by the stream, the one above the other. Overlying these there is a congeries of the remains of aquatic plants, which must have grown and decayed on the spot for many ages after the soil had so changed that trees could be produced by it no longer; and over the whole there occur layers of mosses, that must have found root on the surface after the waters had been drained away by the deepening channel of the river. The six thousand years are here represented by that morass, its three succeeding forests, its beds of aquatic vegetation, its bands of moss, and the thin stratum of soil which overlies the whole. Well, but it forms, notwithstanding, only the mere beginning of a formation. Pile up twenty such morasses, the one over the other; separate them by a hundred such bands of alluvial silt as we have just examined a little higher up the stream; throw in some forty or fifty thick beds of sand to swell the amount; and the whole together will but barely equal the Coal Measures, one of many formations.*

But the marine deposits of the present creation have been perhaps accumulating more rapidly than those of our lakes, forests, or rivers? Yes, unques-

tionably, in friths and estuaries, in the neighbourhood of streams that drain vast tracts of country, and roll down the soil and clay swept by the winter rains from thousands of hill-sides; but what is there to lead to the formation of sudden deposits in those profounder depths of the sea, in which the water retains its blue transparency all the year round, let the waves rise as they may? And do we not know that along many of our shores the process of accumulation is well-nigh as slow as on the land itself? The existing creation is represented in the little land-locked bay, where the crustacea harbour so thickly, by a deposit hardly three feet in thickness. In a more exposed locality, on the opposite side of the promontory, it finds its representative in a deposit of barely nine inches. It is surely the present scene of things that is in its infancy! Into how slender a bulk have the organisms of six thousand years been compressed! History tells us of populous nations, now extinct, that flourished for ages: do we not find their remains crowded into a few streets of sepulchres? 'Tis but a thin layer of soil that covers the ancient plain of Marathon. I have stood on Bannockburn, and seen no trace of the battle. In what lower stratum shall we set ourselves to discover the skeletons of the wolves and bears that once infested our forests? Where shall we find accumulations of the remains of the wild bisons and gigantic elks, their cotemporaries? They must have existed for but comparatively a short period, or they would surely have left more marked traces behind them.

When we appeal to the historians, we hear much of a remote antiquity in the history of man: a more

than twilight gloom pervades the earlier periods; and the distances are exaggerated, as objects appear large in a fog. We measure, too, by a minute scale. There is a tacit reference to the three score and ten years of human life: and its term of a day appears long to the ephemera. We turn from the historians to the prophets, and find the dissimilarity of style indicating a different speaker. Ezekiel's measuring-reed is graduated into cubits of the temple. The vast periods of the short-lived historian dwindle down into weeks and days. Seventy weeks indicated to Daniel, in the first year of Darius, the time of the Messiah's coming. Three years and a half limit the term of the Mohammedan delusion. Seventeen years have not yet gone by since Adam first arose from the mould; nor has the race, as such, attained to the maturity of even early manhood. But while prophecy sums up merely weeks and days when it refers to the past, it looks forward into the future, and speaks of a thousand years. Are scales of unequally-graduated parts ever used in measuring different portions of the same map or section—scales so very unequally graduated, that while the parts in some places expand to the natural size, they are in others more than three hundred times diminished? If not—for what save inextricable confusion would result from their use—how avoid the conclusion, that the typical scale employed in the same book by the same prophet represents similar quantities by corresponding parts, whether applied to times of outrage, delusion, and calamity, or set off against that long and happy period in which the spirit of evil shall be bound in chains and darkness,

and the kingdom of Christ shall have come? And if such be the case—if each single year of the thousand years of the future represents a term as extended as each single year of the seventeen years of the past—if the present scene of things be thus merely in its beginning—should we at all wonder to find that the formation which represents it has laid down merely its few first strata?

The curtain again rises. A last day had at length come to the period of the middle formation; and in an ocean roughened by waves and agitated by currents, like the ocean which flowed over the conglomerate base of the system, we find new races of existences. We may mark the clumsy bulk of the *Holoptychius* conspicuous in the group; the shark family have their representatives as before; a new variety of the *Pterichthys* spreads out its spear-like wings at every alarm, like its predecessors of the lower formation; shoals of fish of a type more common, but still unnamed and undescribed, sport amid the eddies; and we may see attached to the rocks below substances of uncouth form and doubtful structure, with which the oroctyologist has still to acquaint himself. The depositions of this upper ocean are of a mixed character: the beds are less uniform and continuous than at a greater depth. In some places they consist exclusively of sandstone, in others of conglomerate; and yet the sandstone and conglomerate seem, from their frequent occurrence on the same platform, to have been formed simultaneously. The transporting and depositing agents must have become more partial in their action than during the earlier period. They

had their foci of strength and their circumferences of comparative weakness; and while the heavier pebbles which compose the conglomerate were in the course of being deposited in the foci, the lighter sand which composes the sandstone was settling in those outer skirts by which the foci were surrounded. At this stage, too, there are unequivocal marks in the northern localities, of extensive denudation. The older strata are cut away in some places to a considerable depth, and newer strata of the same formation deposited unconformably over them. There must have been partial upheavings and depressions, corresponding with the partial character of the depositions; and, as a necessary consequence, frequent shiftings of currents. The ocean, too, seems to have lessened its general depth, and the bottom to have lain more exposed to the influence of the waves. And hence one cause, added to the porous nature of the matrix and the diffused oxide, of the detached, and, if I may so express myself, church-yard character of its organisms.

Above the blended conglomerates and sandstones of this band a deposition of lime took place. Thermal springs, charged with calcareous matter slightly mixed with silex, seem to have abounded, during the period which it represents, over widely-extended areas; and hence probably its origin. An increase of heat from beneath, through some new activity imparted to the Plutonic agencies, would be of itself sufficient to account for the formation. I have resided in a district in which almost every spring was charged with calcareous earth; but in cisterns or draw-wells, or the utensils in which the housewife stored up for use

the water which these supplied, no deposition took place. With boilers and tea-kettles, however, the case was different. The agency of heat was brought to operate upon these; and their sides and bottoms were covered, in consequence, with a thick crust of lime. Now, we have but to apply the simple principles on which such phenomena occur, to account for widely-spread precipitates of the same earth by either springs or seas, which at a lower temperature would have been active in the formation of mechanical deposits alone. The temperature sunk gradually to its former state; the purely chemical deposit ceased; the waters became populous as before with animals of the same character and appearance as those of the upper conglomerate; and layer after layer of yellow sandstone, to the depth of several hundred feet, were formed as the period passed. With this upper deposit the system terminated.

Though fish still remained the lords of creation, and fish of apparently no superior order to those with which the vertebrata began at least three formations earlier, they had mightily advanced in one striking particular. If their organization was in no degree more perfect than at first, their bulk at least had become immensely more great. The period had gone by in which a mediocrity of dimension characterized the existences of the ancient oceans, and fish armed offensively and defensively with scales and teeth scarcely inferior in size to the scales and teeth of the gavial or the alligator, sprung into existence. It must have been a large jaw and a large head that contained, doubtless among many others, a tooth an

inch in diameter at the base. I may remark, in the passing, that most of the teeth found in the several formations of the system are not instruments of mastication, but, like those in most of the existing fish, mere hooks for penetrating slippery substances, and thus holding them fast. The rude angler who first fashioned a crooked bone, or a bit of native silver or copper, into a hook, might have found his invention anticipated in the jaws of the first fish he drew ashore by its means; and we find the hook-structure as complete in the earlier ichthyolites of the Old Red Sandstone as in the fish that exist now. The evidence of the geologist is of necessity circumstantial evidence, and he need look for none other; but it is interesting to observe how directly the separate facts bear, in many examples, on one and the same point. The hooked and slender teeth tell exactly the same story with the undigested scales in the fœcal remains alluded to in an early chapter.

In what could this increase in bulk have originated? Is there a high but yet comparatively medium temperature in which animals attain their greatest size, and corresponding gradations of descent on both sides, whether we increase the heat until we reach the point at which life can no longer exist, or diminish it until we arrive at the same result from intensity of cold? The line of existence bisects on both sides the line of extinction. May it not probably form a curve, descending equally from an elevated centre to the points of bisection on the level of death? But whatever may have been the cause, the change furnishes another instance of analogy between

the progress of individuals and of orders. The shark and the sword-fish begin to exist as little creatures of a span in length; they expand into monsters whose bodies equal in hugeness the trunks of ancient oaks; and thus has it been with the order to which they belong. The teeth, spines, and palatial bones of the fish of the Upper Ludlow Rocks are of almost microscopic minuteness; an invariable mediocrity of dimension characterizes the ichthyolites of the Lower Old Red Sandstone; a marked increase in size takes place among the existences of the middle formation; in the upper the bulky *Holoptychius* appears; the close of the system ushers in the still bulkier *Megalichthys;* and low in the Coal Measures we find the ponderous bones, buckler-like scales, and enormous teeth of another and immensely more gigantic *Holoptychius*—a creature pronounced by Agassiz the largest of all osseous fish.* We begin with an age of dwarfs—we end with an age of giants. The march of Nature is an onward and an ascending march; the stages are slow, but the tread is stately; and to Him who has commanded, and who overlooks it, a thousand years are as but a single day, and a single day as a thousand years.†

* There have been fish-scales found in Burdiehouse five inches in length, by rather more than four in breadth. Of the gigantic *Holoptychius* of this deposit we have still much to learn. The fragment of a jaw, in the possession of the Royal Society of Edinburgh, which belonged to an individual of the species, is 18½ inches in length; and it is furnished with teeth, one of which, from base to point, measures five inches, and another four and a half.

† See on this subject the introductory note to the present edition, and note p. 203.

We have entered the Coal Measures. For seven formations together—from the Lower Silurian to the Upper Old Red Sandstone—our course has lain over oceans without a visible shore, though, like Columbus in his voyage of discovery, we have now and then found a little floating weed, to indicate the approaching coast. The water is fast shallowing. Yonder passes a broken branch, with the leaves still unwithered; and there floats a tuft of fern. Land, from the mast-head! land! land!—a low shore thickly covered with vegetation. Huge trees of wonderful form stand out far into the water. There seems no intervening beach. A thick hedge of reeds, tall as the masts of pinnaces, runs along the deeper bays, like water-flags at the edge of a lake. A river of vast volume comes rolling from the interior, darkening the water for leagues with its slime and mud, and bearing with it to the open sea, reeds, and fern, and cones of the pine, and immense floats of leaves, and now and then some bulky tree, undermined and uprooted by the current. We near the coast, and now enter the opening of the stream. A scarce penetrable phalanx of reeds, that attain to the height and well-nigh the bulk of forest-trees, is ranged on either hand. The bright and glossy stems seem rodded like Gothic columns; the pointed leaves stand out green at every joint, tier above tier, each tier resembling a coronal wreath or an ancient crown, with the rays turned outwards; and we see atop what may be either large spikes or catkins. What strange forms of vegetable life appear in the forest behind! Can that be a club-moss that raises its slender height for more than fifty feet from the soil? Or can these tall

palm-like trees be actually ferns, and these spreading branches mere fronds? And then these gigantic reeds! —are they not mere varieties of the common horse-tail of our bogs and morasses, magnified some sixty or a hundred times? Have we arrived at some such country as the continent visited by Gulliver, in which he found thickets of weeds and grass tall as woods of twenty years' growth, and lost himself amid a forest of corn fifty feet in height? The lesser vegetation of our own country, reeds, mosses, and ferns, seems here as if viewed through a microscope: the dwarfs have sprung up into giants, and yet there appears to be no proportional increase in size among what are unequivocally its trees. Yonder is a group of what seem to be pines—tall and bulky, 'tis true, but neither taller nor bulkier than the pines of Norway and America; and the club-moss behind shoots up its green hairy arms, loaded with what seem catkins above their topmost cones. But what monster of the vegetable world comes floating down the stream—now circling round in the eddies, now dancing on the ripple, now shooting down the rapid? It resembles a gigantic star-fish, or an immense coach-wheel divested of the rim. There is a green dome-like mass in the centre, that corresponds to the nave of the wheel or the body of the star-fish; and the boughs shoot out horizontally on every side, like spokes from the nave, or rays from the central body. The diameter considerably exceeds forty feet; the branches, originally of a deep green, are assuming the golden tinge of decay; the cylindrical and hollow leaves stand out thick on every side, like prickles of the wild rose on the red, fleshy,

lance-like shoots of a year's growth, that will be covered two seasons hence with flowers and fruit. That strangely-formed organism presents no existing type among all the numerous families of the vegetable kingdom. There is an amazing luxuriance of growth all around us. Scarce can the current make way through the thickets of aquatic plants that rise thick from the muddy bottom; and though the sunshine falls bright on the upper boughs of the tangled forest beyond, not a ray penetrates the more than twilight gloom that broods over the marshy platform below. The rank steam of decaying vegetation forms a thick blue haze, that partially obscures the underwood; deadly lakes of carbonic acid gas have accumulated in the hollows; there is silence all around, uninterrupted save by the sudden splash of some reptile fish that has risen to the surface in pursuit of its prey, or when a sudden breeze stirs the hot air, and shakes the fronds of the giant ferns or the catkins of the reeds. The wide continent before us is a continent devoid of animal life, save that its pools and rivers abound in fish and mollusca, and that millions and tens of millions of the infusory tribes swarm in the bogs and marshes. Here and there, too, an insect of strange form flutters among the leaves. It is more than probable that no creature furnished with lungs of the more perfect construction could have breathed the atmosphere of this early period, and have lived.

Doubts have been entertained whether the limestone of Burdiehouse belongs to the Upper Old Red Sandstone or to the inferior Coal Measures. And the fact may yet come to be quoted as a very direct proof

of the ignorance which obtained regarding the fossils of the older formation, at a time when the organisms of the most of the other formations, both above and below it, had been carefully explored. The Limestone of Burdiehouse is unequivocally and most characteristically a Coal-Measure limestone. It abounds in vegetable remains of terrestrial or lacustrine growth, and these, too, the vegetables common to the Coal Measures—ferns, reeds, and club-mosses. One can scarce detach a fragment from the mass, that has not its leaflet or its seed-cone enclosed, and in a state of such perfect preservation, that there can be no possibility of mistaking its character. If in reality a marine deposit, it must have been formed in the immediate neighbourhood of a land covered with vegetation. The dove set loose by Noah bore not back with it a less equivocal sign that the waters had abated. Now in the Upper Old Red Sandstone, none of these plants occur. The deposit is exclusively an ocean deposit, and the remains in Scotland, until we arrive at its inferior and middle formations, are exclusively animal remains. Its upper member, "the yellow sandstone," says Dr. Anderson of Newburgh, "does not exhibit a single particle of carbonaceous matter—no trace or film of a branch having been detected in it, though, if such in reality existed, there are not wanting opportunities of obtaining specimens in some one of the twenty or thirty quarries which have been opened in the county of Fife, in this deposit alone." No two bordering formations in the geological scale have their boundaries better defined by the character of their fossils than the Old Red Sandstone and the Coal Measures.

We pursue our history no further. Its after course is comparatively well known. The huge sauroid fish was succeeded by the equally huge reptile—the reptile by the bird—the bird by the marsupial quadruped; and at length, after races higher in the scale of instinct had taken precedence in succession, the one of the other, the sagacious elephant appeared, as the lord of that latest creation which immediately preceded our own. How natural does the thought seem which suggested itself to the profound mind of Cuvier, when indulging in a similar review! Has the last scene in the series arisen, or has Deity expended his infinitude of resource, and reached the ultimate stage of progression at which perfection can arrive? The philosopher hesitated, and then decided in the negative, for he was too intimately acquainted with the works of the Omnipotent Creator to think of limiting his power; and he could, therefore, anticipate a coming period in which man would have to resign his post of honour to some nobler and wiser creature—the monarch of a better and happier world. How well it is to be permitted to indulge in the expansion of Cuvier's thought, without sharing in the melancholy of Cuvier's feeling—to be enabled to look forward to the coming of a new heaven and a new earth, not in terror, but in hope—to be encouraged to believe in the system of unending progression, but to entertain no fear of the degradation or deposition of man! The adorable Monarch of the future, with all its unsummed perfection, has already passed into the heavens, flesh of our flesh, and bone of our bone, and Enoch and Elias are there with him—fit representatives of that

dominant race, which no other race shall ever supplant or succeed, and to whose onward and upward march the deep echoes of eternity shall never cease to respond.

ICHTHYOLITES OF THE OLD RED SANDSTONE.

FROM AGASSIZ'S "POISSONS FOSSILES."

⁂ The synonomes here—now supplanted, however,—with the names of a few doubtful or fictitious species, are given in *italics;* —the former opposite the names ultimately adopted, the latter immediately under the names of the determined species.

Acanthodes pusillus.
Actinolepis tuberculatus.
Asterolepis Asmusii.—Syn. *Chelonichthys Asmusii.*
  〃 apicalis.
  〃 granulata.
  〃 Hœninghausii.
  〃 Malcolmsoni.
  〃 minor.—Syn. *Chelonichthys minor.*
  〃 ornata.
  〃 speciosa.
  〃 *concatenatus.*
  〃 *depressus.*
Bothriolepis favosa.—Syn. *Glyptosteus favosus.*
  〃 ornata 〃 *reticulatus.*
Byssacanthus arcuatus.
  〃 crenulatus.
  〃 lævis.
Cephalaspis Lewisii.
  〃 Lloydii.
  〃 Lyellii.
  〃 rostratus.

Cheiracanthus microlepidotus.
" minor.
" Murchisoni.
Cheirolepis Cummingiæ.
" Traillii.
" Uragus.
" *splendens.*
" *unilateralis.*
Chelyophorus pustulatus.
" Verneuilii.
Cladodus simplex.
Climatius reticulatus.
Coccosteus cuspidatus.
" decipiens.—Syn. *latus.*
" maximus.
" oblongus.
Cosmacanthus Malcolmsoni.
Cricodus incurvus.—Syn. *Dendrodus incurvus.*
Ctenacanthus ornatus.
" serrulatus.
Ctenodus Keyserlingii.
" marginalis.
" parvulus.
" Worthii.
" *radiatus.*
" *serratus.*
Ctenoptychius priscus.
Denrodus latus.
" minor.
" sigmoides.
" strigatus.
" tenuistriatus.
Diplacanthus crassispinus.
" longispinus.
" striatulus.
" striatus.
Diplopterus affinis.
" borealis.—Syn. *Agassizii.*
" macrocephalus.
Dipterus macrolepidotus.
" *arenaceus.*

Dipterus *brachypygopterus.*
″ *macropygopterus.*
″ *Valenciennesii.*
Glyptolepis elegans.
″ leptopterus.
″ microlepidotus.
Glyptopomus minor.—*Platygnathus minor.*
Haplacanthus marginalis.
Holoptychius Andersoni.
″ Flemingii.
″ giganteus.
″ Murchisoni.
″ Nobilissimus.
″ Omaliusii.
Homacanthus arcuatus.
Homothorax Flemingii.
Lamnodus biporcatus.—SYN. *Dendrodus biporcatus.*
″ hastatus.—SYN. *Panderi. Dendrodus hastatus, compressus.*
″ sulcatus.
Narcodes pustilifer.
Naulas sulcatus.
Odontacanthus crenatus.—SYN. *Ctenoptychius crenatus.*
″ heterodon.
Onchus heterogyrus.
″ semistriatus.
″ sublævis.
Osteolepis arenatus.
″ macrolepidotus.
″ • major.
″ microlepidotus.
″ *intermedius.*
″ *nanus.*
Pamphractus Andersoni.
″ Hydrophilus.—SYN. *Pterichthys Hydrophilus.*
Parexus recurvus.
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Platygnathus Jamesoni.
″ paucidens.
Polyphractus platycephalus.

Psammosteus arenatus.—SYN. *Placosteus arenatus.*
" mæandrinus. " " *mæandrinus.*
" paradoxus. " *Psammolepis paradoxus.*
" undulatus. " *Placosteus undulatus.*
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" cornutus.
" major.
" Milleri.
" latus.
" oblongus.
" productus.
" testudinarius.
Ptychacanthus dubius.
Stagonolepis Robertsoni.

THE END.

BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

Wednesday, September 23, 1840.

SECTION C.—GEOLOGY AND PHYSICAL GEOGRAPHY.

Mr. Lyell in the chair.

"Mr. Murchison gave an account of the investigations and discoveries of Mr. Hugh Miller of Cromarty (now Editor of the *Witness*) in the Old Red Sandstone. Various members of a great family of fishes, existing only in a deposit of the very highest antiquity, had been discovered by Mr. Miller, Dr. Fleming, Dr. Malcolmson, and other gentlemen. M. Agassiz had found these fishes to be characterized by the peculiarity of not having the vertebral column terminated at the centre of the tail, as in the existing species, but at its extremity. He spoke in the highest terms of Mr. Miller's perseverance and ingenuity as a geologist. With no other advantage than a common education, by a careful use of his means, he had been able to give himself an excellent education, and to elevate himself to a position which any man in any sphere of life might well envy. Mr. Murchison added, that he had seen some of Mr. Miller's papers on Geology, written in a style so beautiful and poetical, as to throw plain geologists like himself into the shade. (Cheers.) The fish discovered by Mr. Miller, one or two fine specimens of which were on the table, was yet without a name; and perhaps M. Agassiz, who would now favour them with a description of the class to which it belonged, would assign it one.

"M. Agassiz stated, that since he first saw, five or six years ago, the fishes of the old deposits, they had increased to such an extent as to enable them to connect them with one large geological epoch. This had been still farther established by their having been found in the same formation by Mr. Murchison in Russia, and Mr. Miller in Ross-shire. These fishes were characterized in the most

curious way he had ever seen. After briefly adverting to their peculiarities, as illustrated by the specimens on the table, M. Agassiz proposed to call Mr. Miller's the *Pterichthys Milleri.* In the course of a subsequent conversation, the learned Professor added, that in lately examining the eggs of the salmon, he had observed that in the fœtal state of these fishes they have that unequally divided condition of tail which characterizes so large a portion of the fishes in the older strata, and which becomes so rare in the fishes of the cretaceous and post-cretaceous formations.

"Dr. Buckland said, he had never been so much astonished in his life by the powers of any man as he had been by the geological descriptions of Mr. Miller, which had been shown to him in the *Witness* newspaper by his friend Sir C. Menteath. That wonderful man described these objects with a felicity which made him ashamed of the comparative meagreness and poverty of his own description in the *Bridgewater Treatise,* which had cost him hours and days of labour. He (Dr. B.) would give his left hand to possess such powers of description as this man; and if it pleased Providence to spare his useful life, he, if any one, would certainly render the science attractive and popular, and do equal service to Theology and Geology. It must be gratifying to Mr. Miller to hear that his discovery had been assigned his own name by such an eminent authority as M. Agassiz; and it added another proof of the value of the meeting of the Association, that it had contributed to bring such a man into notice."—*Extract from the Report of the Proceedings of the Association.*

"Il semble que de toute part le terrain dévonien acquiert une nouvelle importance. M. Hugh Miller vient de faire connaître en détail, dans un joli volume intitulé '*The Old Red Sandstone,*' toutes les richesses que ce terrain renferme dans les environs de Cromarty. Le premier, il

a découvert ces fossiles de forme bizarre, à caractères hétérognes, que l'on a tantôt voulu ranger parmi les Tortues, tantôt parmi les Crustacés, et que quelques naturalistes ont même pris pour de grands Coléoptères aquatiques, et dont je crois avoir reconnu la véritable nature, en les rangeant parmi les poissons, ou ils forment un genre à part que j'ai désigne sous le nom de Pterichthys."—*Agassiz.*

"This admirable work, the production of a man who obtained his geological knowledge while working day by day as a labourer in a quarry of the Old Red Sandstone in the north-east part of Scotland, evinces talent of the highest order, a deep and healthful moral feeling, a perfect command of the finest language, and a beautiful union of philosophy and poetry. No geologist can peruse this volume without instruction and delight. It affords an admirable synopsis of the formations between the granitic schists and the coal measures, and indeed embraces an enlarged and highly philosophical view of the science, and of its relation to the Creator."—*Professor Silliman.*

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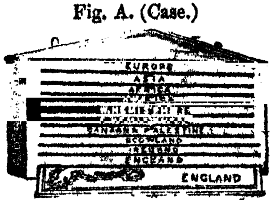

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